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AUTHOR Siegel, Martin A.; Clapp, Elizabeth Jane
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ABSTRACT

The 2 year project (July 1, 1978 through June 30, 1980) sought to determine the viability, attractiveness, and effectiveness of computer based instruction with approximately 225 severely and profoundly mentally handicapped and developmentally disabled institutionalized children and adults. Over 100 instructional formats were developed by staff from the PLATO Education Group of the Computer-based Education Research Laboratory, University of Illinois at Urbana-Champaign. Skills addressed included basic language and math skills important to academic instruction. A direct instruction model was used for designing the computer based lessons. The means of delivering this instruction was the PLATO system, a sophisticated computer based instructional system utilizing a versatile graphics and touch sensitive terminal. The research suggested that carefully designed PLATO materials could provide effective and efficient instructional services not currently offered by other media. (Author)

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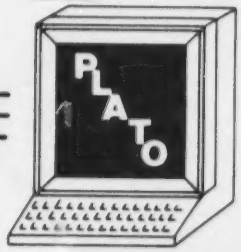

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THE DEVELOPMENT OF PLATO® COMPUTER-BASED INSTRUCTION FOR THE SEVERELY AND PROFOUNDLY DEVELOPMENTALLY DISABLED

MARTIN A. SIEGEL

ELIZABETH JANE CLAPP

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CERL REPORT E-22

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THE DEVELOPMENT OF PLATO COMPUTER-BASED INSTRUCTION FOR THE SEVERELY AND PROFOUNDLY DEVELOPMENTALLY DISABLED

Martin A. Siegel
Elizabeth Jane Clapp

Computer-based Education Research Laboratory
University of Illinois at Urbana-Champaign

December 1981

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ABSTRACT

In recent years, concern has arisen over the quality of educational services available to handicapped citizens. Of particular interest to the Illinois State Department of Mental Health and Developmental Disabilities (DMHDD) planners are those persons, both adults and juveniles, who are currently institutionalized or are in danger of becoming institutionalized. This two year project (July 1, 1978 - June 30, 1980) sought to determine the viability, attractiveness, and effectiveness of computer-based instruction with severely and profoundly mentally handicapped and developmentally disabled persons. Residents and staff at the William A. Howe Center, which serves adults, and at the Herman Adler Mental Health Center, which serves children, participated in the study. Over 100 instructional formats were developed by staff from the PLATO Education Group of the Computer-based Education Research Laboratory (CERL), University of Illinois at Urbana-Champaign.

Skills addressed included basic language and math skills important to academic instruction. A direct instruction model was used for designing the computer-based lessons. The means of delivering this instruction was the PLATO system, a sophisticated computer-based instructional system utilizing a versatile graphics and touch sensitive terminal. The research conducted at Howe and Adler suggested that carefully designed PLATO materials could provide effective and efficient instructional services not currently offered by other media. Since application of computer-based technology in this area is in its infancy, this developmental effort may lead the way in defining models for effective use of this medium in the education of the severely and profoundly developmentally disabled.

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BACKGROUND

Population Description and Educational Requirements

Definitions of Severely Handicapped

There are no widely agreed upon definitions of the severely handicapped. Sontag, Burke, and York (1973) defined the severely handicapped in terms of a variety of behaviors which prevent their acquiring general basic skills and information from their environment. They point out that without drastic environmental manipulations, these students will not acquire the bases for more normalized living.

The Bureau of Education for the Handicapped (BEH) defines the severely handicapped in terms of needed services which are not traditionally provided by the special education units in public schools. Handicapped citizens require these special services in order to maximize their potential for self-fulfillment (Thompson, 1974).

Abt Associates (1974) attempted to provide a more functional definition by listing deviant behaviors which generally result in the definition of severely handicapped. These behaviors have aspects in common which would tend to isolate the individual from normal channels of learning.

In 1976, Justen formulated a definition which stresses the educational needs of the severely handicapped individual. These educational needs are such that extensive structuring of the learning situation must occur if the individuals are to receive appropriate education (Justen, 1976).

All definitions share in common the severely handicapped individual's need for extensive and specialized training (Brown and York, 1974; Gold, 1976). This project has shared a view of the handicapped person as presenting behavioral deficits which can be remediated through adequate environmental programming, rather than as suffering from an irreversible condition resulting from impaired intellectual functioning (Bijou, 1963; Lindsley, 1964; Myerson, Michael, Mower, Osgood, and Staats, 1960).

Capabilities of the Severely Handicapped

Research has supported the notion that, given sufficiently well-structured training, severely and profoundly handicapped individuals can achieve competence in a variety of self-help and vocational tasks. These tasks range from folding and pasting of cake cartons (Loos and Tizard, 1955) to assembly of a 52 piece cam switch actuator (Bellamy, Peterson, and Close, 1975). These and other instances of severely and profoundly retarded people learning to function independently in vocational tasks make irrelevant the question of whether this population can learn. Instead, the focus falls on the question of how they can best be taught.

Educational Requirements for the Severely Handicapped

Task analysis. A variety of reseachers have emphasized the need for appropriate task analysis as the basis for effective and efficient design of educational programs for severely handicapped individuals (Williams, 1975; Brown and others, 1976). The specifications of tasks and their components constitute one of the bases for instructional programs for the severely handicapped. Principles for task and concept analysis have been explicated by Engelmann (1969) and Becker (1971).

Measurement. Concomitant to the need for appropriate task and concept analysis is the requirement that a student's control of the concept or operation be accurately assessed at each step of the instruction. This population has difficulty generalizing skills across persons, places, and materials. Furthermore, it is dangerous for an instructor to make inferences about sets of skills on the basis of skill samples. For these reasons, direct measurement of the existence of the target response, skill, or concept is a necessary part of an effective instructional program (Brown and York, 1974). Direct measurement of component skills is particularly necessary in the teaching of cumulative tasks represented by such developmental skills as mathematics, reading, language, speech, and practical arts (Brown, 1973).

Rate. Another consideration in the development of any educational program for the severely handicapped is the establishing of rate criteria for the performance of tasks. Williams, Brown, and Certo (1977) point out that a skill cannot be considered mastered unless it can be performed at an acceptable rate. Without appropriate rate of response, even a correct performance by the student may not be acceptable to the community. Slow performance may also interfere with a student's capacity to remember the steps in a cumulative task. In the absence of sufficient research in the application of rate criteria in educational settings, two alternatives exist for teaching acceptable rate of performance of a cumulative task: 1) in a skill composed of A, B, and C, to require that A be performed at an acceptable rate before moving on to B, and so forth; and 2) to teach A, B, and C and then to impose a rate criterion on the combined skill.

Generalization. Of concern to teachers of severely handicapped students is the provision that skills learned in a given setting be manifested in other appropriate, though not identical, situations. Brown and others (1976) propose that teachers adopt a "zero degree inference strategy." No inferences concerning the generalization of a skill can be made unless the skill has been demonstrated in a minimum of three different settings--with different persons, instructional materials, extraneous stimuli, and cues to respond.

A number of strategies to teach generalization exist, although there is little experimental data to identify that which is most effective. One strategy, systematic variation, was demonstrated to yield positive results by Barrett and McCormack (1973) working with severely handicapped institutionalized individuals. Rincover and Koegel (1975) identified the

problem as being one of stimulus control. Controlled changes in stimulus settings resulted in generalization. In a later study, Koegel and Rincover (1977) state that for a program to be effective it must promote both generalization and maintenance of the skill over time.

Pomerantz (1976) points out the danger of artificial settings in training situations and argues that the closer the training setting is to the natural setting in which the skill is to be manifested the greater the chance that generalization will occur. It is also the case, however, that more natural settings provide less control over teaching variables. The importance of controlling all such variables was pointed out earlier.

Thus, educating the student with special needs often involves a "total environment" approach. The process includes the determination of entry and terminal behaviors, the analysis of tasks that lead to the design of effective instruction, the review of previously acquired skills, the fading of prompts, the control of changes in stimulus settings resulting in generalization, and the continuous collection of data throughout the program. Such a process is indeed challenging and often time consuming.

Role of Computers in Education

Computers in education can serve dual functions -- as instructional delivery systems and as instructional management systems. As O'Neil and Paris (1981) point out, the use of computers for instructional purposes has several advantages. Among these are such things as: the possibility of quickly updating instructional material, the provision for consistently high-quality instruction (instructor variability is eliminated) that is available on a large scale and to remote areas, the opportunity for interactive (performance-based) oriented instruction, the possibility of continuous feedback, and the ability to provide optimally individualized instruction.

The individualization of instruction requires accurate and up-to-date information on the performance of the persons involved; it is in this sphere that the management function of computers takes on importance. According to Baker (1981) the functions of computer-managed instruction include: data collection, testing to diagnose and prescribe, performance monitoring, scheduling, resource allocation, and data reporting. Systems providing such information make it possible for designers, instructors, and administrators to provide precisely the type of instruction an individual needs.

The PLATO Computer-based Instruction (CBI) System

PLATO is a computerized teaching, communications and information network, developed and centered at the Computer-based Education Research Laboratory, University of Illinois at Urbana-Champaign. Development and testing of the system have spanned more than 20 years. The users of PLATO range from grade school students learning reading and mathematics to graduate students

in law and medical sciences. The system now has over 1,200 terminals located in universities, colleges, community colleges, public schools, military training schools, commercial organizations, adult learning centers, and prisons. The users have access to more than 8,000 hours of instructional material in more than 150 subject areas. Since 1972, PLATO IV has recorded nearly 10 million hours of usage by students and lesson writers.

The central computer is a dual mainframe consisting of a Control Data Corporation 6500 computer working in tandem with a Cyber 73-24 computer. These two machines together have nearly 200,000 sixty-bit words of central memory storage. There are four central processing units, and twenty peripheral processing units. Permanent storage for the computer programs and lessons is provided by an electromagnetic disk system consisting of eighteen disk drives with a capacity for storing over two hundred million sixty-bit words of data.

In order for hundreds of terminals to run simultaneously with key-response times of one eighth of a second or less, the lessons are taken from their permanent storage on the disk and put into a very fast and relatively low cost swapping memory called extended core storage. There are currently two million words of extended core storage memory, as well as five million words of another kind of fast memory called auxilliary mass storage. The lessons are then swapped in and out of the central memory for processing by the central processors. This time-sharing architecture has resulted in very fast transfer and retrieval rates, at relatively low cost.

Communications between the central computer and the terminals is handled by two communications interface units. From the communications interface units, the information is transmitted by phone line to one-, four-, or eight-terminal modems, or by microwave to thirty-two terminal site controllers. Information from the terminal to the computer goes to the modems or site controllers which multiplex the information onto a single telephone line and transmit it to the computer. Each terminal is guaranteed an average of 2.3 inputs per second, which has proven to be adequate for current needs. The system is generally scheduled to be available twenty-three hours a day, and system reliability is very high--more than 95% of the scheduled time has been available to users.

The PLATO terminal has a plasma display screen which is composed of a grid of 512 x 512 plasma "dots" which can be lighted or turned off under computer control. Text can be written across the screen at a speed of 180 characters per second, and the programmer can specify graphs and line drawings as well as specially designed character sets. Input to the terminal is via a keyset and a touch sensitive screen. The keyset has all the standard typewriter keys together with special function keys which can be programmed to perform whatever operations are needed for individual lessons. The latest generation of terminals, the PLATO V terminals, has a new plasma panel with expanded capabilities, and has incorporated a microprocessor which can be used for local processing along with the central computer.

A random-access audio device, which resembles a record player, can also be connected to the terminal to deliver auditory messages to the students at appropriate times. The configuration is completed by a random-access slide selector which rear projects color images onto the display screen.

The PLATO system provides a means for individualized, self-paced, and interactive instruction to large numbers of students at once. This unique and non-traditional learning medium can be an effective teaching aid for the juvenile or adult learner (for example see Siegel, et al., 1978, and Dugdale and Kibbey, 1977). Attitudinal data indicates that PLATO is thought of as a patient, motivating, and non-threatening "tutor." It complements and supplements classroom instruction and frees the instructor for special work with students, an advantage which conventional teaching does not usually include. Furthermore, PLATO's data handling capabilities and computational power made it uniquely suited to the type of research described in this report. (For a more complete description of the PLATO system, see Smith and Sherwood, 1976, and Lyman, 1977).

There are several points at which the use of computers, specifically the PLATO system, can aid in the educational process for the severely handicapped. The availability of a touch panel, for instance, makes it possible for a student to respond simply by touching the screen. Such a response medium is attractive since it allows the learner to focus on the concept at hand and makes it possible for those with limited language skills to demonstrate what they know. Using a computer to deliver instruction means that not only is variability of a given lesson's delivery eliminated, but that, in addition, a student may proceed through a lesson at his own pace and may repeat it as often as necessary. A well-designed management system allows the student to return to previous lessons to review a skill as often as he wishes. Generalization of a skill is made possible through two means: a) careful sequencing of lessons so that the student is led to review in increasingly difficult situations, and b) having a pool of items from which to draw each time a lesson is entered so that he is not faced with precisely the same lesson upon subsequent entries (i.e. while the basic lesson itself remains the same, the items used in the lesson differs). Data collection and reporting is possible at all points, tracking a student's progress through lessons. By specifying in the program itself what information is to be kept, it is done automatically and may be accessed at any time by the instructor.

Early Non-PLATO CBI Work with the Severely Handicapped

Few computer-based instruction (CBI) projects have addressed themselves directly to the severely handicapped person. The projects that did develop materials for this population were limited by hardware and curriculum configurations. Moreover, severely and profoundly handicapped persons were not included in test populations. Nonetheless, early work was encouraging.

In a program operated by the Montgomery County Public Schools of Rockville, Maryland, eight Educable Mentally Handicapped (EMH) children, selected as being most likely to benefit, received 40-50 minutes per week of drill and

practice in basic number facts on the IBM 1500 system, which uses a cathode-ray type terminal. The children gained 1.24 years in .7 years (Dunn, 1974).

Another experiment exploring the feasibility of using CBI with EMH children was conducted by Nelon in Syracuse, New York. Vocabulary drill requiring children to fill in the blanks with appropriate choices or to supply the missing letter in a word, given the definition of the word, was delivered to 12 EMH children and 12 normal children matched for mental age. Drill was delivered via teletype terminals. The two groups learned equally well. Nelon commented, however, on the distracting noisiness of the teletype terminals and the need for a capacity to deliver audio messages to the children (Nelon, 1972).

Both hardware and courseware limitations have, in the past, hampered fruitful exploration of the use of CBI with severely and profoundly developmentally disabled persons. Some of these limitations follow:

Hardware Limitations

1. None of the terminals used in the projects allowed students to respond through any device but the keyset.

2. None of the terminals were successfully equipped with audio.

3. None of the terminals offered dynamic graphic display.

4. None of the terminals possessed a means of displaying color images.

Courseware Limitations

1. With almost no exception, courseware was limited to drill and practice.

2. With no exception, interacting successfully with the lessons required basic reading skills and the ability to respond by using a keyset.

3. Little effort was made to define precisely the ways in which the CBI curriculum could optimally fit into the student's total education program.

4. Little effort was made to exploit the power of the computer to store, manipulate, and display data for use by designers and teachers in making instructional decisions.

Early PLATO CBI Work with the Severely Handicapped

On PLATO too, exploration of CBI for the severely handicapped is still relatively young. Some of the early work included several small projects initiated to begin assessment of the utility of PLATO IV as an instructional technology for the mentally handicapped and developmentally disabled. For example, with the participation of the Institute of Child Behavior and Development of the University of Illinois, educators at Howe Developmental Center explored applications of PLATO technology to the teaching of severely and profoundly mentally handicapped persons. In 1976, one PLATO terminal was placed at the Center. Resident usage of PLATO averaged about forty hours per month. Programs used included lessons at the basic reading level (developed for elementary school children) along with a few lessons developed to teach pre-reading skills.

Additionally, in 1977, two fully-equipped PLATO terminals were placed in operation at the Adler School, the educational facility of the Herman Adler Mental Health Center. The type of installation at Adler made it possible to move the terminals from room to room and, consequently, observe learning behavior with PLATO lessons in the classroom, in one-to-one tutoring lessons, and in a library setting. These terminals were used to deliver reading and mathematics instruction to children with a wide variety of disabilities: emotional disturbance; receptive and expressive aphasia; behavioral disorders; and rare genetic syndromes. Demonstrated IQ's ranged from above normal to 60; some children, however, had problems such that IQ could not be readily assessed. Usage of the terminals by Adler students averaged about sixty-five hours a month.

PROJECT GOALS

Broad Aims and Long-Range Objectives

The goal of this project was to determine the viability, attractiveness, and effectiveness of PLATO computer-based instruction for severely and profoundly developmentally disabled persons. This project formed the first two steps in a seven step plan for developing on a larger scale PLATO services for the developmentally disabled. The seven steps of this plan are outlined below. (Funds were not provided for steps 3-7.)

1. Assess the viability and attractiveness of PLATO to DMHDD institutions and residents.

2. Develop and assess the instructional effectiveness of a small number of model lessons developed specifically for the severely and profoundly developmentally disabled.

3. Compare the instructional effectiveness of PLATO to that of other methods.

4. Compare the cost-effectiveness of PLATO instruction to that of other methods.

5. On the basis of information derived from steps 1-4 define the role of PLATO in DMHDD programs for the developmentally disabled.

6. Given that a role has been identified for PLATO in DMHDD educational services, implement a major developmental effort to create additional lesson materials based on the models developed in step 2.

7. Develop and carry out plans for implementing PLATO on a suitable scale throughout the DMHDD system.

Specific Aims of the Two-Year Project

The specific aims of the two year project were:

1. To develop a set of pilot lessons on PLATO designed to teach selected pre-academic language and math skills to severely and profoundly developmentally disabled persons.

2. To explicate the instructional methods used in the lessons.

3. To implement the instructional lessons with residents at the Howe and Adler centers.

4. To evaluate the effectiveness of the instructional lessons used.

5. To develop a set of guidelines for the implementation of these lessons in the total instructional setting.

6. To develop a set of recommendations for future developmental efforts.

METHODS

Role of CERL and Cooperating Institutions

Work to provide appropriate and effective instruction on PLATO for severely and profoundly developmentally disabled persons involved the cooperation of three institutions:

1. The Computer-based Education Research Laboratory (CERL) of the University of Illinois at Urbana-Champaign.

2. The William A. Howe Developmental Center, an Illinois Department of Mental Health and Developmental Disabilities residential facility.

3. The Herman Adler Mental Health Center, an Illinois State DMHDD residential facility.

It should be noted that each of the cooperating institutions involved already had access to PLATO terminals. These terminals were located in the buildings where they were needed. Therefore procurement and installation of PLATO terminals did not constitute part of this project and will not be discussed here.

Computer-based Education Research Laboratory

The Computer-based Education Research Laboratory of the University of Illinois at Urbana-Champaign was established in 1967 to explore computer applications of educational goals. Since that time the Laboratory has developed several generations of computer-assisted instruction systems, called PLATO (Programmed Logic for Automated Teaching Operations). With each generation, the PLATO system has increased in instructional versatility, ease of lesson writing, and power to reach many students at once with individualized programs.

Presently CERL stands unique among computer-assisted instruction laboratories for its continuous service to educational institutions. Computer-assisted instruction emanating daily from CERL reaches students of all ages in settings ranging from university and medical school campuses to first grade public school classrooms to residential facilities for the developmentally disabled.

The roles of CERL included the following:

1. To provide and maintain PLATO service at Adler and Howe centers.

2. To design and implement instructional sequences on PLATO.

3. To design and make available teaching materials to be used in conjunction with PLATO lessons.

4. To design and implement orientation for Howe and Adler staff working with students on PLATO.

5. To design and participate appropriately in the implementation of formative and summative evaluation.

6. To write and disseminate all reports and other documentation of the implementation and findings of the proposed project.

The William A. Howe Developmental Center

The William A. Howe Developmental Center, established in 1974, is a residential facility located in Tinley Park, Illinois and operated by the Illinois Department of Mental Health and Developmental Disabilities. Howe is fully certified as an Intermediate Care Facility for the Developmentally Disabled by the Illinois Department of Public Health and DHEW. The facility was designed to reflect normal aspects of community living as much as possible and is, therefore, made up of five separate "neighborhoods" or units, each with its own administrative and clinical staff. Each unit has ten individual residential homes with eight residents living in each home. This utilization/decentralization model is used effectively in both the provision of services and in the administrative management of the facility as well.

The Howe Center serves about 360 residents who are developmentally disabled and 18 years of age or older. The majority (75%) of residents have been evaluated as functioning in the severe or profound ranges of retardation. Howe emphasizes the Interdisciplinary Team approach in the delivery of individualized services to each resident. Each Interdisciplinary Team is composed of a physician, several nurses, two psychologists, social worker, educator, vocational coordinator, the Home Supervisor, who is responsible for the resident's home, and the direct-care staff who work in the home in which the resident lives. Recognizing the fact that each resident has unique developmental needs, this team designs individual habilitation plans for each person. These habilitation plans describe the various training objectives and program plans for each individual resident. A "developmental model" is followed in structuring training programs; i.e., certain behaviors are pre-requisites for more complex adaptive behaviors. As adaptive behaviors increase and skills are acquired, it becomes possible for residents to go to less restricted living arrangements within the community.

A wide array of programs and services has been required in order to meet the differing developmental needs of Howe residents. For example, supported by an Illinois Office of Education, Division of Adult Vocational Technical Education grant, basic employment skills training projects serving 107 residents have been established by the facility. In addition, 92 residents currently attend vocational workshops and work in activity centers in the community. P.L. 94-142, The Education for All Handicapped Children Act, which requires school districts to assure that special education is being provided for all handicapped children in the "least restrictive environment," has resulted in arrangements for some Howe residents (in the 18-21 age category) to attend public school classes in the community. In addition, the Federal Title I grant program (ESEA Title I - P.L. 89-313 as amended by P.L. 93-380) serves 68 residents in

classrooms at Howe supervised by State of Illinois-certified educators. Other professional services offering developmental opportunities in recreational, socialization, self-help and other areas have been implemented both inside and outside the residential houses.

The Herman Adler Mental Health Center

The Herman Adler Mental Health Center is a residential treatment facility operated by the State of Illinois Department of Mental Health and Developmental Disabilities as part of a regional mental health services program. Adler Center provides residential treatment services for developmentally disabled, seriously emotionally disturbed, and socially maladjusted children up to sixteen years of age from a 16-county area of Eastern Illinois. This area supports a population of 800,000, one-third aged 0-18. With space available for a total of 45 children, the Adler Center provides a second level of services as a backup resource for community agencies in the region. All referrals for residential treatment are made through community mental health centers and developmental services centers, which are funded by State grant-in-aid.

The Adler residential treatment programs include four types of admissions:

1. Regular admissions, rarely exceeding one year.

2. Assessment and evaluation admissions, usually not exceeding ten weeks.

3. Respite care admissions of up to two weeks to provide relief to parents, maintain skill levels, and prevent long-term institutionalization.

4. Emergency admissions, with assessment and planning to be completed within ten days.

Treatment programs are based upon a psycho-educational model with psychiatric evaluations and consultations for all emotionally disturbed children and psychiatric treatment where indicated. Each child receives a highly individualized treatment program designed by an Adler inter-disciplinary team and a community coordinator from the child's subregion. Parents, public school personnel, and representatives from other community agencies also participate in the treatment plan design and implementation, since changes usually must also occur within the family, school and community for the child to make a successful adjustment.

Role of Cooperating Institutions

The roles assumed by the Adler and Howe Centers were the following:

1. To identify residents who could potentially benefit from instruction on PLATO.

2. To assure that these residents receive regular access to appropriate PLATO instruction.

3. To identify tutors who will work well with the residents chosen for instruction.

4. To carry out specified procedures to assure that PLATO instruction is integrated into other aspects of the resident's instructional program.

5. To offer criticisms of programs developed with a view to improving the usefulness of educational effectiveness of these programs.

6. To provide access to relevant educational data on participating students for the purposes of evaluating the effectiveness of the PLATO programs.

Several features of the PLATO IV system enhanced the ability of the cooperating institutions to carry out their functions, participate in the design and revision of courseware developed for their use, and receive the advice and support of the development group.

(Due to a substantial shift in the Adler population during the second year of the project, the experimental portion of the project was not implemented at Adler; however, a PLATO pre-GED and GED program was provided. This will be described in a later section.)

Computer Aids to Cooperation

Assurance that students received regular access to PLATO was facilitated by two features. The first was a systems-level record-keeping program automatically associated with each student. The following data were automatically recorded:

1. The date on which each student's record was initiated.

2. The number of sessions the student had engaged in.

3. The last date on which the student signed on the system.

4. The total number of hours the student had spent on the system.

5. The date and duration of each student's session on PLATO.

6. The lessons which the student encountered.

7. The time spent on each lesson.

These records were continuously available and could be instantly accessed on-line by PLATO designers and instructors who had authorization to inspect such information. By this means those responsible for assuring that students had regular access could tell at a glance whether students were receiving appropriate levels of exposure.

The role of integrating PLATO lessons into other aspects of the student's instructional program was facilitated by use of the computer-based instructional management system (SYS III). SYS III required no expertise with computers for its use. It allowed the teacher to assign specified lessons to a given student or group of students. After a brief training session, teachers could use the instruction management system to integrate PLATO programs into their instructional plans.

While teachers at Howe and Adler were directly responsible for seeing that students received their instruction on PLATO, close contact was also maintained between the teachers and the developers of the lessons. Four communications features of the PLATO IV system maximized exchange of ideas while minimizing the need for frequent special meetings.

1. The "talk" option. This option permited an instantaneous typed "telephone conversation" between two PLATO users. The typed dialogue appeared at the bottom of the PLATO screen of each person involved in the conversation.

2. The monitor option. This option combined the "talk" capacity with a feature which allowed two users at different locations to simultaneously view the same screen display. Thus two people at different sites observed and made comments on a lesson in operation.

3. The personal notes option. This option resembled an electronic personal letter. The "letter" is written on-line. When a person signed on to the system he was automatically notified if there were any notes for him. If there were, he went to his own private file, inaccessible by anyone else, and read and replied to his notes.

4. The group notes option. This option somewhat resembled a personal notes option, except that it allowed a specified larger group of persons (as opposed to two individuals) to write, read, and respond to notes kept in a computer-stored serial file. Thus, a group discussion took place on the computer. If desired, this discussion was printed and distributed or archived on paper.

5. The comments option. This feature allowed an instructor to type his comments directly on the display the student was interacting with. (The typing appeared unobtrusively at the bottom of the display.) The computer then stored both the comment and the frame of the lesson in which the comment occurred. This information was then made accessible to the developers of the lesson and formed the basis for improvement of the lesson.

These features made possible frequent and extensive exchange of ideas among developers and users. The computer-based equivalent of telephone calls, letters, and conferences could be utilized at any time of the day or night. Communication could thus be achieved when it was needed and without disruption of other scheduled duties.

First Project Year: July 1, 1978 - June 30, 1979

The first year of this project was spent carrying out the following tasks:

1. Intensive observation of the students and the environments in which they were expected to function, with a view to identifying the most directly and immediately useful skills.

2. Examination of training programs to determine which skills were least adequately covered by present teaching methods and materials.

3. Analysis of prospective concepts and skills to be taught with a view to identifying clusters of those which were mutually reinforcing and which were most fundamental to the development of higher-level skills.

4. Further analysis of the resulting suitable concepts to select those most suitable for presentation on PLATO.

Meetings were held with the administrative staffs of the Howe and Adler Centers to review the current usage of PLATO. It was important to the future success of this project for both centers to maintain a current, high level of interest and familiarity with PLATO during the planning phase. Both Howe and Adler were incorporated into a basic skills lesson delivery system currently being used also by the public schools in Champaign-Urbana and the Illinois Department of Corrections in their facilities throughout the state (Siegel, et al., 1978). The William A. Howe Center used the newly-acquired lesson material in an on-going General Equivalency Diploma (GED) program offered to their direct care staff. The Herman Adler Center scheduled students from their adolescent classrooms to new work available at that level in reading comprehension, mathematics, and related subjects.

During site visits to the Howe and Adler Centers, the CERL staff was able to obtain an overview of the total educational programs described earlier in this report and to assess the part that future PLATO lesson development could play in enhancing the programs already in progress. The specific staff group which would be responsible for tutoring residents on PLATO was identified, and the resident population for whom lessons would be designed was defined. Skill areas to be considered in PLATO lesson development were discussed at length and listing of those skill areas were obtained from all the staff members involved in educational planning at each center.

Role of PLATO in the Total Education Programs

At the Howe Center, the curriculum of the Adult Basic Education (ABE) classrooms was outlined and explained. Residents currently in that program (68 persons) received instruction in pre-academic and academic skills daily. Other educational programs for residents who qualified below that level were conducted in the housing units and consisted of vocational,

self-care and safety training based on behavioral objectives. The Howe educational planning staff was most interested in providing alternate tutorial materials for their unit-based educational program. Their hope was to be able to channel more of the students from that program into the ABE classroom.

The Adler Center continued to function as a school modeled as closely as possible on the standard public school classroom to which most of their residents would, hopefully, return. There was a large amount of one-to-one tutoring which occured in addition to the individualization of instruction in each classroom. The Adler school was interested in using PLATO generated materials with as many children as could be served in all settings within the school. The functional level of incoming referrals was dropping due to the efforts of public education, in compliance with P.L. 94-142, to mainstream special students. As a consequence, the need for pre-academic lesson material at Adler increased.

Staff Involvement with PLATO

The staff of the Howe Center became increasingly more sophisticated in the use of PLATO. In addition to the design and programming skills gained by several of the planning personnel in past years, at least 10 direct care staff members took advantage of the GED study materials available on PLATO. This first-hand experience was valuable in the selection and training of tutors for residents in the project's implementation. The educational planning team gained experience in assigning topics to GED students, and the lesson delivery system available to them closely paralleled the one to be used in scheduling residents.

Adler Center staff involvement with PLATO also increased once they began assigning lessons using the new delivery system. The Adler school administration was interested in using their para-professional staff to full advantage. The senior staff was then more available to engage in more detailed diagnosis and remediation planning in conjuction with PLATO and other school programs. The para-professional staff was selected to be trained as PLATO tutors and functioned as aides to classroom teachers using PLATO.

Selection of Residents for PLATO Instruction

This project, as originally proposed, sought to lay a foundation for computer-based services for:

1. Residents who needed vocational or pre-vocational training, but who lacked fundamental language and math skills.

2. Residents who required a structured, stimulating, intensive teaching environment to make progress in such basic skills as fine motor coordination, receptive language acquisition, and other communication skills.

3. Residents who required training in basic attending skills in order to make progress in learning.

4. Residents who displayed motivational and behavioral problems which interfered with learning

Over 200 of the residents at Howe and well over half the residents at Adler (of a total of 45) had the above disabilities.

The William A. Howe Center categorized its population as follows:

a) Has not reached criterion on attending program: does not attend to simple "table tasks".

b) Attends; may do simple matching tasks, but does not identify pictures.

c) Can identify pictures, but does not read words.

d) Reads one to ten words.

e) Reads over ten words.

Residents from categories b and c above were selected as recipients of the proposed PLATO instruction. This represented about 56% of the population.

At the Adler school those students who comprised the second and third lowest functioning classroom were selected for inclusion in the implementation. These students range in age from 5 to 12 years of age and were diagnosed as functioning within the same range as those selected from the Howe Center.

Skill Areas

Based on discussions with Howe and Adler educational staff as well as analyses of the pre-academic programs for severely and profoundly developmentally disabled learners, a set of skill areas were defined. Lists of topics were developed, refined, and 108 formats were eventually programmed on the PLATO computer for use with the students at Howe and Adler (although the usage at Adler was minimal due to shifting populations). The final list of formats will be presented in a later section of this report.

Each of the final skill areas was taught in three phases: 1) student and tutor; 2) student and tutor and PLATO; and 3) student and PLATO. Appropriate pointing and touching procedures were demonstrated by the tutor. All teaching formats had the following form: a) model; b) lead; and c) test. The tutor modeled or demonstrated the appropriate behavior; the tutor did the appropriate behavior with the student (lead); and the student performed the appropriate behavior without assistance. The following is an example of a phase two format (student, tutor, and PLATO).

Phase Two Format

This format was developed for a lesson to teach recognition of objects and discrimination among a set of objects. The objects used in this example are a star, a face, and a box. The lesson is intended for initial introduction of objects, and requires the presence and participation of a tutor. The first column of the outline indicates what touch or keyset input was expected. The second column indicates what appeared on the PLATO screen. The last column indicates what cues were given for the tutor to say. These events are sequenced linearly down the page. For example, in the first step, the tutor is cued to say, "Watch the screen." Then the tutor pressed a key which causes a star to be displayed on the screen. After a short delay, the star erases.

Note that all steps were controlled and sequenced by the computer. The role of the tutor was to read the script (appearing at the top of the screen), assist the student in making the appropriate response (touching or saying), and indicate to the computer (by pressing a key) when the next step should be initiated.

	Touch or Keyset Input	Screen Display	Cue to Tutor
(1)			"watch the screen"
	Tutor keypress		
		star	
			"star"
		(delay)	
		(star erases)	
(2)	[repeat (1)]		
(3)			"watch the screen"
	tutor keypress		
		star	
			"watch me touch the star" (use touch behavior taught off-line)
	tutor touch		
		star glows	
		(star erases)	
(4)	[repeat (3)]		
(5)			"watch the screen"
	tutor keypress		
		star	
			"get ready... you touch the star"
	student touch (using touch behavior taught off-line)		
		star glows	
		(star erases)	
(6)	[repeat (5) until student has made 3 consecutive correct touches]		

(7)			"watch the screen"
	tutor keypress		
		star	
			"get ready... you touch the star"
	student touch		
		(star glows)	
			"what is it?" (student says "star" may need to lead)
	tutor keypress		
		(star erases)	

(8) [repeat (7) until 3 consecutive correct touches with the correct responses]

(9)			"watch the screen"
	tutor keypress		
		1 star, 3 faces (objects randomly arranged)	
			"get ready... you touch the star"
	student touch		
		(star glows)	
			"what is it?" (student says "star")
	tutor keypress		
		(star erases)	

(10) [repeat (9) until 3 consecutive correct touches with the correct responses]

(11)-(20) [repeat steps (1) through (10) using a box in the place of the star. the box fills up in response to a correct touch. in step (7), stars are used as foils]

(21)			"watch the screen"
	tutor keypress		
		star	
			"get ready... you touch the star"
	student touches		
		(star glows)	
			"what is it?"
	tutor keypress		
		(star erases)	

(22) [repeat (21) until 3 consecutive correct touches with the correct responses]

(23)-(24) [repeat steps (21) and (22) with a box instead of a star]

(25)			"watch the screen"
	tutor keypress		
		1 star, 1 box (object randomly ordered)	
			"get ready... you touch the star"
	student touch		
		(star glows)	
			"what is it?"

(26) [repeat (25) until 3 consecutive correct touches with the correct responses]

(27) [repeat (25)-(26) touching box instead of star]

(28) [repeat (25) randomly asking the student to touch the star or the box. repeat until 5 consecutive correct touches with the correct responses]

(29)-(38) [repeat steps (1) through (10) using a face in the place of the star. the face smiles in response to a correct touch. in step (7), boxes are used as foils.]

(39)-(40)	[repeat steps (21)-(22)]		
(41)-(42)	[repeat steps (21) and (22) with a face instead of a star]		
(43)-(46)	[repeat (25)-(28) using face in place of box]		
(47)-(48)	[repeat steps (21)-(22) with a box instead of a star]		
(49)			"watch the screen"
	tutor keypress		
		1 star 1 box 1 face (objects randomly ordered)	
			"get ready... you touch the box"
	student touch		
		(box fills in)	
			"what is it?"
(50)	[repeat (49) until 3 consecutive correct touches with correct responses]		
(51)	[repeat (49)-(50) touching face instead of box]		
(52)	[repeat (49)-(50) touching star instead of box]		
(53)	[repeat (49) randomly asking the student to touch the star, box, or face. repeat until 5 consecutive correct touches with correct responses.]		
(51)	[repeat (49)-(50) touching face instead of box]		

Lesson Structure

During the second half of the first year, the design team finalized several learning formats and decided what skills and tasks would be taught. One full-time professional programmer wrote the lesson code and data programs.

Each lesson was organized into skill-learning sequences, formats, and tasks. A sequence was the carefully programmed development of a major skill. A format was one part in the programming of a skill in a given sequence; it was the pattern of teaching steps repeated in a number of successive lessons (for example, a format which teaches a student the names of objects). A task was created by inserting a new set of examples (different objects and questions) into a format pattern.

Lesson design was carried out by the principal investigator and the two principal staff members, with consultation from appropriate persons associated with the cooperating institutions and with CERL. Lessons were blocked out on paper before they were programmed and pilot tested with small numbers of students. During pilot testing, each student was accompanied at his PLATO session by a tutor from the CERL design team. The tutor's job was to read the audio portion of the program and to observe student behaviors which could not be unambiguously picked up thrgh a computer's data-gathering mechanisms: expressions of frustration or enjoyment and signs of confused visual scanning of the display, for instance. Tutors read the audio portion of the program directly from the PLATO screen, where the computer unobtrusively displayed the correct wording at appropriate points in the lesson.

The purpose of having the CERL tutor read audio instructions at this stage was threefold. First, it was necessary for a tutor to be with the student at this stage to gather formative evaluation data. Secondly, the lessons were designed purposely to be administered in the presence of a tutor, to assure that students could deal with the instructions, feedback, and input modes before using PLATO independently or semi-independently. And finally, the CERL tutor could suggest ways to make later drill routines function without the tutor's presence. Construction of teaching procedures designed to fade dependence on the computer terminal was a necessary part of the stimulus situation in which the skill was to be exercised. The developers were acutely aware that generalization of skills was a serious weakness in the functioning of severely and profoundly developmentally disabled persons. Every effort was made in the design both of computer and non-computer teaching materials to foster generalization skills.

Tutor Training

During the second six months of the first year the project staff outlined a tutor training workshop, defined the role of the tutor, composed a tutor training manual, and coordinated with institutional staff in the selection of tutors. Tutor reporting checklists were also drafted and lists were made of potential tutors at each site.

Second Project Year: July 1, 1979 - June 30, 1980

PLATO Program at Adler

Due to a shift in the population served by the Adler school, the decision was made to offer academic instruction via PLATO and SYS III (a computer-based instructional management, evaluation, and communication system). See Appendix A for the Adler catalog. Adler residents were, therefore, not included as a part of the experimental study.

PLATO Program at Howe

The experimental study at Howe involved 12 residents and was run for a period of approximately eight weeks. During this time those residents involved with the study spent thirty minutes a day, three to five days a week using the instructional lessons designed for this project. Immediately prior to the commencement of PLATO instruction, the residents were given an off-line pretest of the concepts to be taught; at the end of the study, the same test was given as a posttest. See Appendix B. The number of subjects in the study was limited to 12 because only one PLATO terminal was available to the institution. It was felt that a concentrated exposure to fewer students rather than a limited exposure to many students would be more representative of a site with many PLATO terminals.

Description of Instructional Strategies

An all too common focus within special education has been on the difficiencies or weaknesses of individual students. Blame for failure is placed at the feet of the student and his malady rather than at the feet of the teacher or the program used. If learning does not occur, the student has a learning disability, and because of the disability the student cannot learn. With this circular reasoning the teacher is excused from self-evaluation since it is the mental retardation, the emotional disturbance, the brain damage, or the learning disability that purportedly accounts for what the student has or has not learned. What the teacher or the program has or has not done is forgotten. This is not to discount the fact that the study of etiology and individual differences can contribute much to the understanding of the nature of learning; unfortunately, however, this approach has led to a neglect of its complement--those teacher behaviors that can account for success and failure in students.

The direct instruction model offers an alternative to this traditional view of teaching the mentally disabled person. It shifts the attention from the person's strengths, weaknesses, or special etiology to the tasks or concepts the person must learn. Whether the task is tying a shoe, reading a word, or carrying out a request, the task itself is the same for everyone. Similarly, the features of the concept red or dog or more than one remain the same no matter who is being asked to learn them. Neither the task nor the concept changes because the individual learning it is developmentally disabled.

The direct instruction model does not ask whether the retarded person can learn, but rather how best the person can be taught. Consequently, the direct instruction approach begins with the assumption that the learner is capable of learning any concept or task or relationship that we wish to teach. If the learner fails, therefore, the fault is not with the learner, but with the instructional sequence. Such a stance implies that failure can be prevented if control is exercised over those details or variables that are within the instructional designers control--the examples used in the presentation, the sequencing of examples, the sequencing of presentations, the wording used, and so forth.

Further, if we believe that the learner is capable of learning concepts, tasks, and relationships consistent with the exposure we provide, we must make sure that this exposure conveys the information that we want it to convey. We must make sure that the communication is as unambiguous as possible so that the learner is able to generalize those concepts to new examples. Doing so involves a unique type of communication--communication through examples. To insure that the learner will not include too much or too little in his generalization, we must be sure that our communication through examples is consistent with only one interpretation.

The achievement of such necessitates the presentation of a series of examples that a) show differences between positive and negative examples, b) show the range of examples, and c) provide a relatively thorough test of the learner's understanding of the generalization. As examples are chosen one must be aware, first of all, that one example cannot possibly teach a generalization since it does not provide a clear and unambiguous message as to what it is that is to be generalized. If the learner is presented with a picture of a large, brown horse in a pasture and told "This is a horse," he is faced with the problem of knowing what it is that he is to focus on and generalize from--the animal, some part of the animal, the location, the presence of a picture frame, etc.

This confusion as to what must be focused on can be alleviated in part through the presentation of several very different positive examples. For a feature to be the basis of a possible interpretation, that feature must be present in all positives. If it is present only in some, it cannot be the basis for classifying the example as a positive. Further presentations of different positive examples of "horse" will enable the learner to focus on the salient features of "horseness." The differences in positive examples imply the range of the concept in question.

The designer must also be aware, however, that a group of positive examples alone cannot provide a communication that is consistent with a single interpretation. Only by presenting negative examples that share a maximal number of features with positive examples can the highest number of possible interpretations be ruled out. For a feature to be the basis for classifying an example as positive, that feature must be present in all positives and no negatives. Therefore, any feature or features shared by positive and negative examples cannot be the basis for a possible interpretation. The greater the number of features shared by a positive and a negative example, the clearer the communication of the critical features of the concept, task, or relationship.

To make maximum use of the samenesses and differences in the features of examples, the above guidelines can be synthesized into five principles of juxtaposition--rules for the careful sequencing of positive and negative examples:

1. Using the same wording for all examples enables the learner to focus on the important details of the items themselves rather than on any variations in the wording. Further, redundancy in the wording implies that each item is to be processed in the same way.

2. Examples which share the greatest possible number of features should be placed close together; again, so that the focus on critical features is maximized, while the focus on non-critical features is minimized or eliminated.

3. Differences in examples are most clearly demonstrated by the juxtapositioning of positive and negative examples that possess minimum differences. When positive and negative examples are placed close together, the small difference between them becomes maximally apparent and eliminates the need for a far-out non-example since the learner should be able to extrapolate to far-out non-examples on the basis of close-in non-examples. (If the learner successfully discriminates between a horse and a zebra, he is not likely to have problems discriminating a horse and a dog.)

4. The juxtapositioning of widely different positive examples and the using of the same label for these examples essentially tells the learner that any differences observed in the positive examples are differences which the bounds of the concept tolerate. In addition, since widely different positive examples demonstrate the range of the concept, the likelihood that the learner will interpolate when faced with mid-range examples is increased.

5. To assess the learner's ability to handle new examples of the concept, examples which bear no predictable relationship to one another must be juxtaposed. The learner is tested on the generalization implied by the communication; if the previous communications have been complete, the learner should be able to deal successfully with new positive and negative examples of the concept.

The precise arrangement of the example to form a teaching presentation is dictated by the type of communication implied by the examples themselves. Teaching a student to correctly label such objects as horse, dog, and zebra requires a communication different from that required to teach on, longer, or the finding of a subject in a sentence.

Of primary interest for this project were those communications involving the sensory features of examples. Such communications fall in one of three areas: single dimension non-comparatives, multiple dimension non-comparatives, and single dimension comparatives. These sensory-based discriminations share the following characteristics: a) the communication

of each type utilizes the presentation and labelling of concrete examples; b) the same response is given to all positive examples; and c) that response is not given to negative examples.

Despite these similarities, however, there are significant differences among the three types. For the single dimension comparative and the single dimension non-comparative a change in a single dimension creates a change in what is postive and what is negative; while for a multiple dimension non-comparative, changes in several dimensions are required to produce negatives. A further difference lies in the fact that examples of single dimension comparatives, as the name imples, have relative values; i.e. for something to be longer it must be compared to something else. Such is not the case for single and multiple dimension non-comparatives.

Lesson Format

Within a conceptual area lessons were designed so that the student was required to make increasingly difficult discriminations. In the prepositions area, for example, the student began with a single object and a single preposition and progressed to multiple objects and multiple prepositions.

Generally, the formats followed a model-test procedure. First the student observed the tutor performing the task; then the student himself was required to perform it. If the student appeared to be having difficulty at the initial stages of a task, the tutor was directed (through the directions at the top of the screen) to lead the student's response, i.e., to provide a physical or verbal prompt to enable the student to begin the task.

In many instances verbal and non-verbal versions of a lesson were available so that the student could respond through a communication mode that did not interfere with the learning of the concept in question. In other words, it could be that the student understood the concept on, but might not be able to verbalize his knowledge because he lacked the language skill necessary to produce the sentence "This _____ is on the table." The non-verbal lessons relied primarily on yes and no responses (which could be indicated in any number of ways) and on the use of the touch panel: "Touch the _____ that is on the table."

Formats were designed in such a way that a single format might be used with multiple related concepts (for instance, the introductory preposition format was used for all prepositions--on, over, under, between--with wording and graphics changes to accommodate each prepostion). The formats were programmed so that during the "testing phase" the students were presented with positive and negative examples in random order. The randomness was necessary in order to ensure that students were learning the concept and not simply a pattern of responses. Such random order is one important factor in leading students to the generalization of a concept. Another important factor is that of the use of a variety of objects in the course of learning the concept. To facilitate this, it was possible for the instructors to choose the object(s) the student was to use each time a

lesson was entered. As a result, though a student might do a given lesson several times, he would not see precisely the same thing each time since the presentation order would be randomized and the object(s) used would be different.

An effort was made, whenever possible, to use positive reinforcement for correct aners as an integral part of the on-line presentation; such was accomplished through the graphics displays by having objects blink or move in some way. These animations appeared to be a valuable aid in the development of attending skills, as well.

Sequencing was another important consideration in the lesson design. After a new member was taught it was discriminated within the context of all previously taught members so that a cumulative and increasingly complex sequence was built. The total sequence was also arranged so that very similar (easily confused) members were separated as much as possible. This was done so that the students would be able to reach a relatively high degree of "firmness" on the concepts before being asked to discriminate one from another.

Sample Formats

Preposition format. The following is a preposition format used for the restricted or introductory presentation of the teaching of on. In the restricted phase there was some danger that the student would stipulate the concept (for example, thinking that on applies only to bowls and tables). During the expanded phase this danger was warded off through the use of a variety of objects and surfaces. In addition, it was expected that during the expanded phase the teaching of on would be reinforced in the students day-to-day activities.

Directions for the tutor appeared at the top of the screen. The tutor wording was found in quotation marks; expected responses and tutor key presses were in parenthesis.

Figure 1. At the beginning of each format the student's attention was directed to the screen.

Fig. 1

Figures 2 and 3. The object identification served several purposes: a) it checked the student's familiarity with the objects so that later possible incorrect responses were the result of not knowing the concept rather than the result of lack of knowledge about the object being used; b) it checked the student's response ability (in a non-verbal format, the student would simply be asked questions requiring yes-no responses); and c) it allowed the student to know that his active involvement through responses would be required.

Fig. 2

Fig. 3

Figure 4. Each time a new example was presented, the student was asked to touch it so that the tutor could be sure the student's attention was directed correctly. Touching the object caused it to blink or move and also changed the tutor's directions. The student's first name appeared rather than "(Student);" for example, "John, touch the bowl."

Fig. 4

Figure 5. This is an example of a negative first format for a single dimension non-comparative. By beginning with a negative example, the naive learner was able to exclude several possibilities from the universe of possibilities that existed prior to the presentation of the example.

Fig. 5

Figures 6 and 7. Another negative example provided still more information about exclusion possiblities. Note that the same object was used throughout the entire presentation so that the learner was not taxed with the job of sorting through extraneous variables. Using the same object made maximally apparent the difference between on and not-on.

'(Student), touch the bowl.'

Fig. 6

'Is the bowl...on? No.'

(Press NEXT.)

Fig. 7

Figures 8 and 9. This was the first positive example. Note the minimal difference between this positive example and the previous negative. Such a difference made the small change from not-on to on clearly noticeable. In addition, this was a powerful example of a continuous conversion presentation (when displayed on a PLATO terminal, of course). Through continuous conversions, students were able to see changes occur--the changes that made positives from negatives and vice versa. This was in stark contrast to static presentations where the learner would simply remember what the previous display was.

'(Student), touch the bowl.'

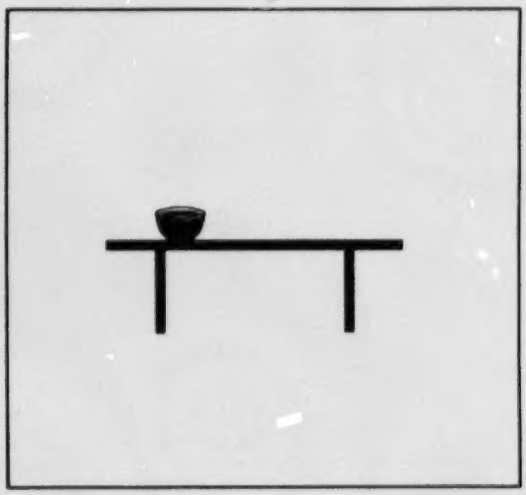

Fig. 8

'Is the bowl...on? Yes.'

(Press NEXT.)

Fig. 9

Figures 10 - 13. Two more positive examples showed the range of the concept in this situation. The wording during the modelling portion was similar to that used during the testing portion, once again minimizing the number of variables the student was faced with. In addition, the tutor was modelling the type of response the student was expected to make.

'(Student), touch the bowl.'

Fig. 10

'Is the bowl...on? Yes.'

(Press NEXT.)

Fig. 11

'(Student), touch the bowl.'

Fig. 12

'Is the bowl...on? Yes.'

(Press NEXT.)

Fig. 13

Figures 14 - 19. This was the beginning of the test. Note that it started with another minimum difference between a positive and a negative. At this point the tutor was instructed to "lead" the student's response; the tutor said the response with the student.

'(Student), touch the bowl.'

Fig. 14

'Is the bowl...on?' (No.)
(Lead response.)
(Press NEXT.)

Fig. 15

"(Student), touch the bowl."

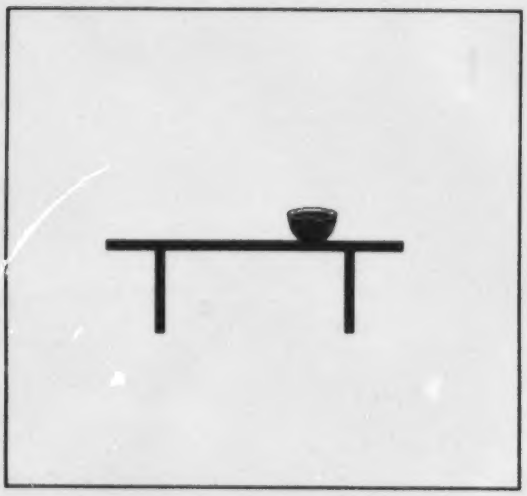

Fig. 16

"Is the bowl...on?" (Yes.)
(Lead response.)
(Press NEXT.)

Fig. 17

"(Student), touch the bowl."

Fig. 18

"Is the bowl...on?" (No.)
(Lead response.)
(Press NEXT.)

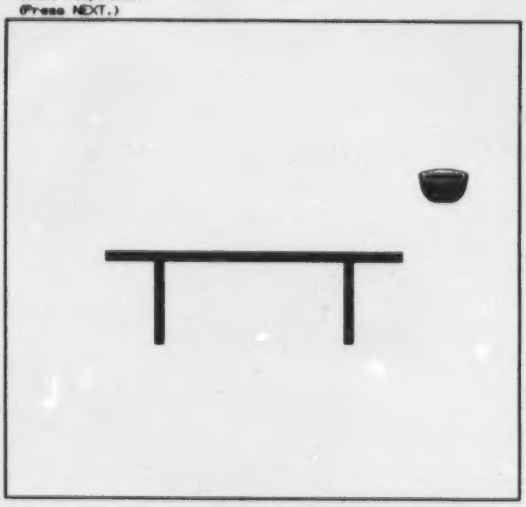

Fig. 19

Figures 20 - 31. During the final part of the test, strong prompts were eliminated as soon as possible. The items were presented in random order so that the student was not responding simply on the basis of a response pattern. Another important consideration, during both testing and modelling, was the use of voice cues. A slight pause before saying the "critical word" (in this case, the preposition "on") and saying it with greater than normal emphasis again focused the student's attention on that critical word. A student saw this format several times--each time with a different object and a random presentation of items during the testing portion.

'(Student), touch the bowl.'

Fig. 20

'Is the bowl...on?' (Yes.)

(Press NEXT.)

Fig. 21

"(Student), touch the bowl."

Fig. 22

"Is the bowl...on?" (Yes.)

(Press NEXT.)

Fig. 23

(Student), touch the bowl."

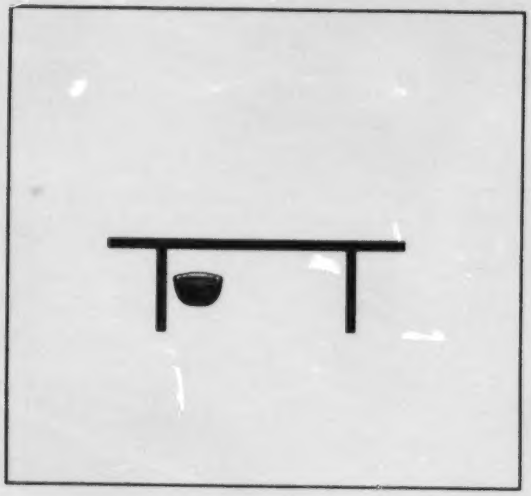

Fig. 24

"Is the bowl...on?" (No.)

(Press NEXT.)

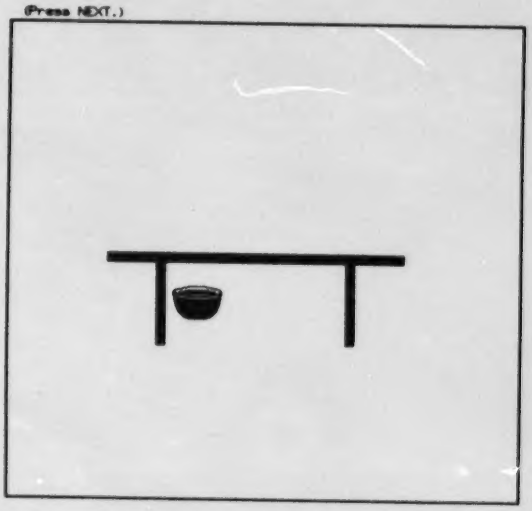

Fig. 25

"(Student), touch the bowl."

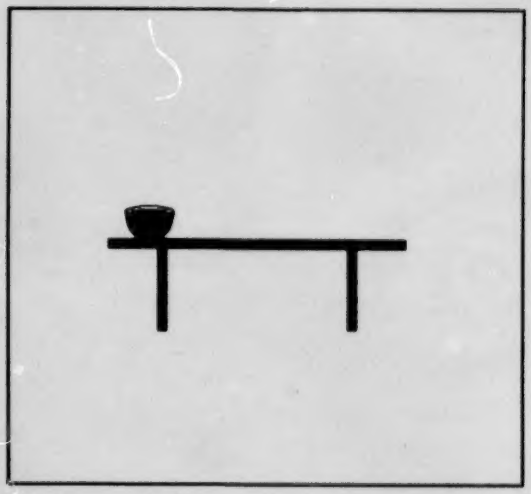

Fig. 26

"Is the bowl...on?" (Yes.)

(Press NEXT.)

Fig. 27

"(Student), touch the bowl."

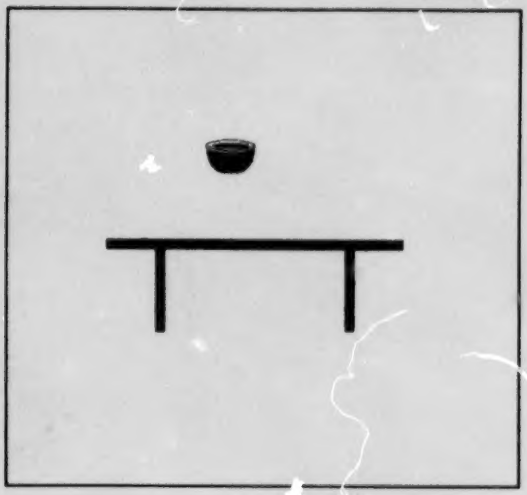

Fig. 28

"Is the bowl...on?" (No.)

(Press NEXT.)

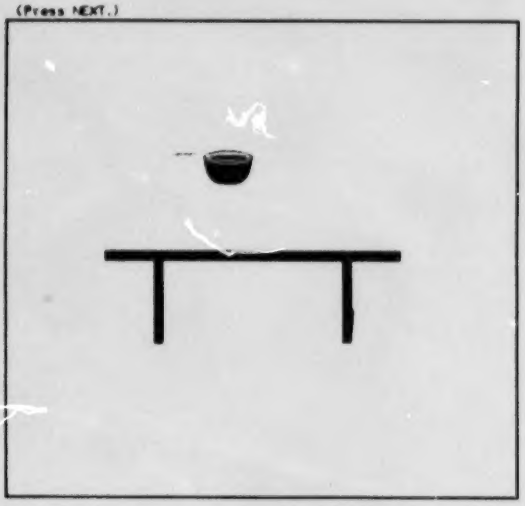

Fig. 29

"(Student), touch the bowl."

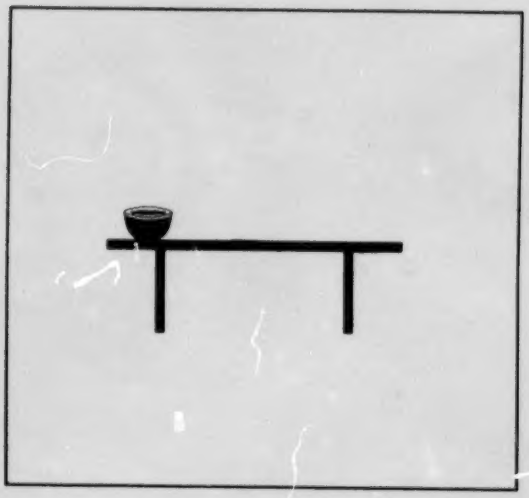

Fig. 30

"Is the bowl...on?" (Yes.)
(Press NEXT.)

Fig. 31

Later preposition formats. As the student advanced in his understanding of on, he was presented with increasingly difficult discriminations. In Figures 32 - 37 the tutor again modelled the behavior; this time three of the same objects were present; some provided positive examples of on, some negative. The test portion began with the student using the same objects the tutor used but placed differently. Then the student moved on to the other objects.

In Figures 38 - 43 the discrimination was made even more difficult, for not only must the student discriminate on from not-on, he must discriminate one type of object from another type. The format presented here required the student to produce a statement after indicating the object was on. A parallel, non-verbal version was available that simply asked the student to make the discrimination without producing the sentence.

Preposition format - same object

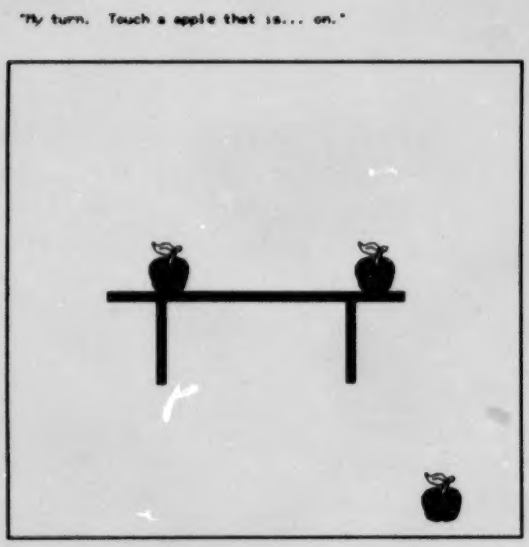

Fig. 32

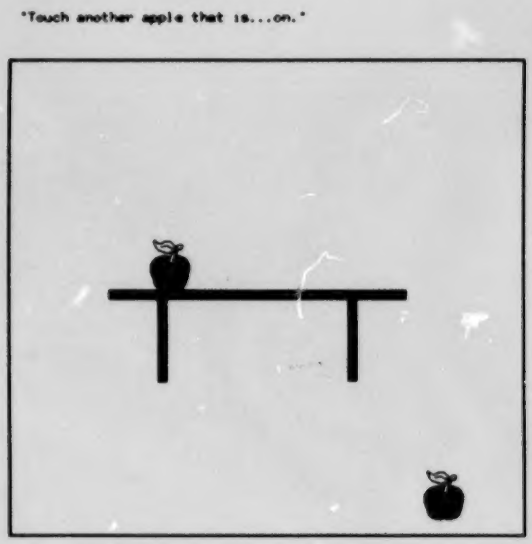

Fig. 33

"Your turn. Touch a apple that is... on."
(Lead response.)

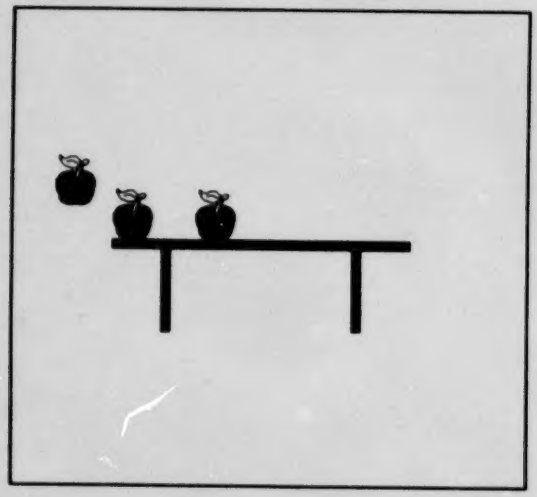

Fig. 34

"Touch another apple that is...on."
(Lead response.)

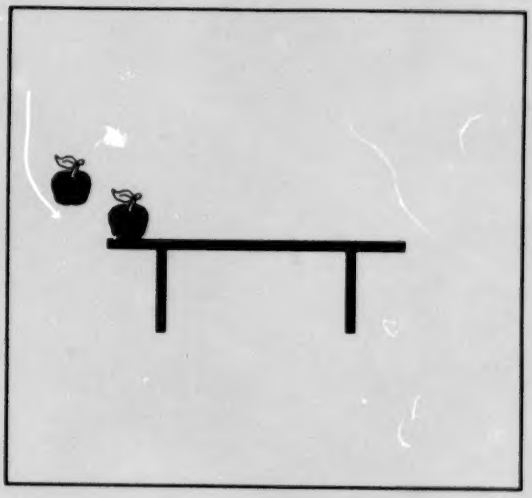

Fig. 35

"Touch a bottle that is...on."

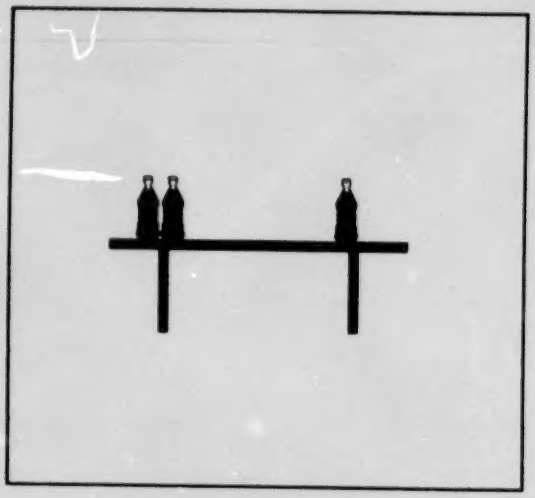

Fig. 36

"Touch another bottle that is...on."

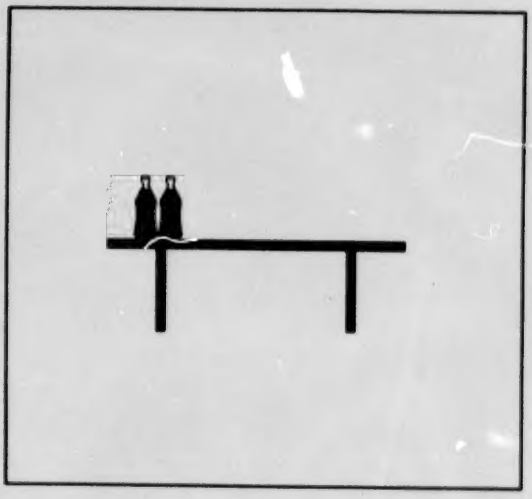

Fig. 37

Preposition format - different objects

"Is the apple...on the table?" (Yes.)
(Lead response.)
(Press NEXT.)

Fig. 38

"Tell me about the apple." (The apple is...on.)
(Lead response.)
(Press NEXT.)

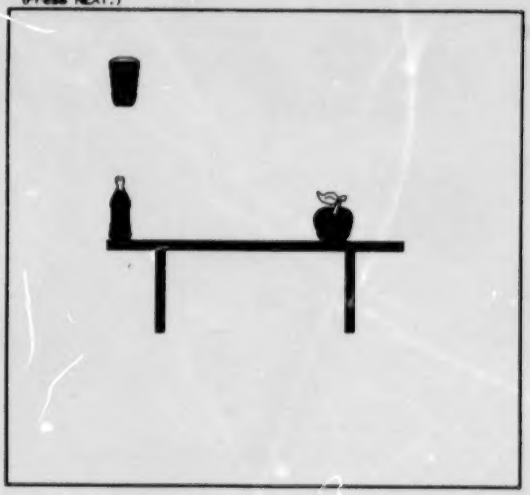

Fig. 39

"Is the glass...on the table?" (No.)
(Lead response.)
(Press NEXT.)

Fig. 40

"Good."
(Press NEXT.)

Fig. 41

"Is the bottle...on the table?" (Yes.)
(Lead response.)
(Press NEXT.)

Fig. 42

"Tell me about the bottle." (The bottle is...on.)
(Lead response.)
(Press NEXT.)

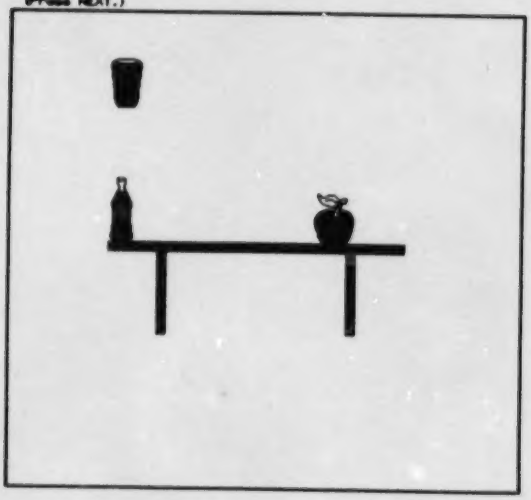

Fig. 43

Polar formats. The polar formats began by teaching each polar in isolation (long, not-long; short, not-short; etc.) and then combining them. Figures 44 - 51 show a later polar format in which the student was expected to discriminate long and short.

"My turn."

(Press NEXT.)

Fig. 44

"Watch me. I'm going to touch a line that is...short."

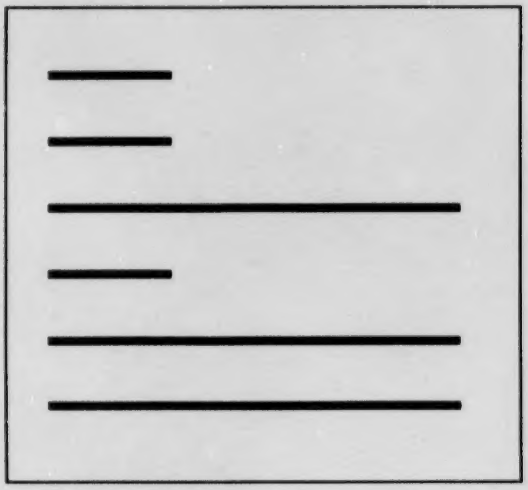

Fig. 45

"Watch me. I'm going to touch a line that is...long."

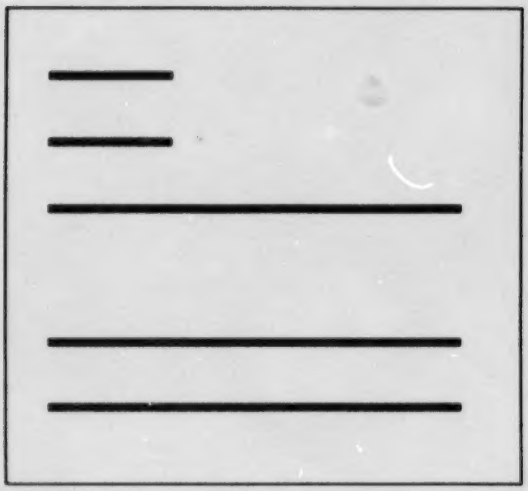

Fig. 46

"Watch me. I'm going to touch another line that is...long."

Fig. 47

"Your turn."

(Press NEXT.)

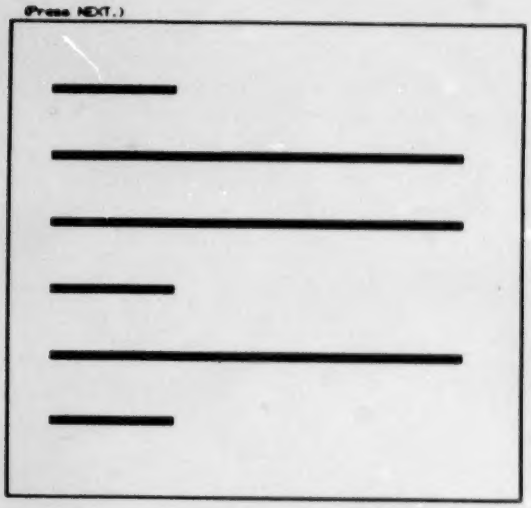

Fig. 48

"Touch a line that is...short."

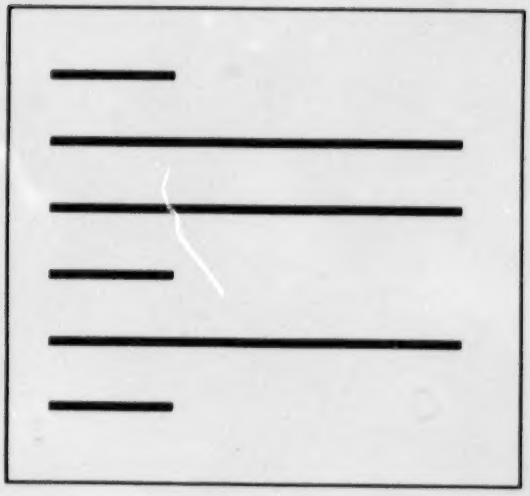

Fig. 49

"Touch a line that is...long."

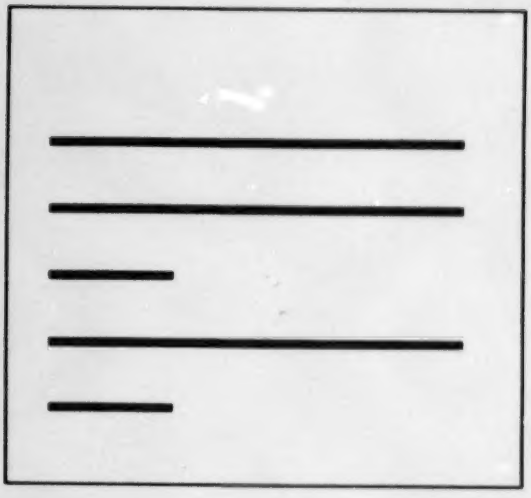

Fig. 50

"Touch another line that is...long."

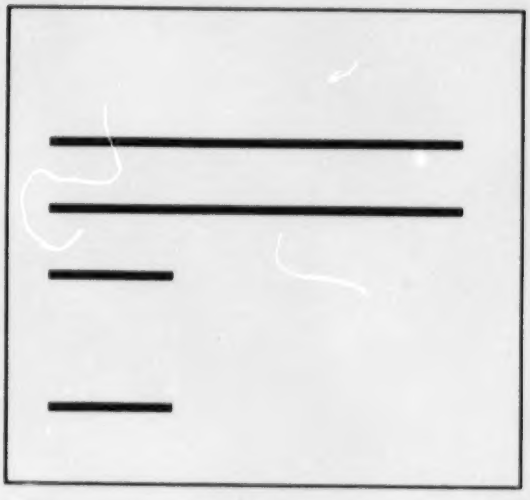

Fig. 51

Tracking and sorting formats. Tracking and sorting were also addressed. Figures 52 - 63 shows a tracking format. Left to right movement was taught through a) erasing boxes already touched; b) an arrow indicating movement to the next box; and c) highlighting the box to be touched. When a box was touched, the contents of the box erased, an arrow extended from the box to the position the object was to occupy, and the part reappeared in the appropriate position.

The sort formats taught the student to sort objects into two to four bags. Initially the student used two bags and his sorting was prompted. At later stages he sorted four bags. The task was made increasingly difficult if the tutor chose objects which were difficult to discriminate from one another. See Figures 64 - 75 for an example of this format.

A tracking format

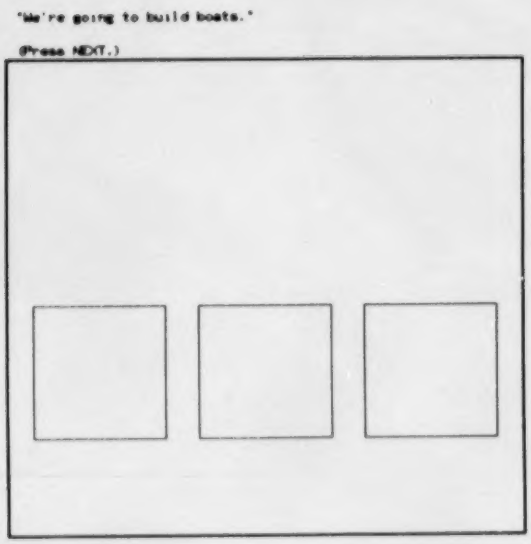

Fig. 52

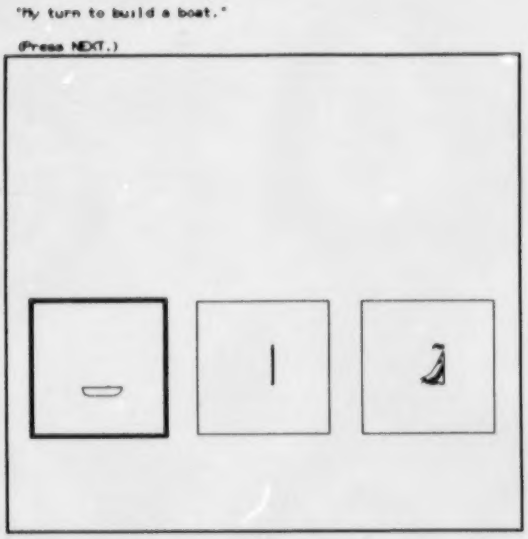

Fig. 53

"Touch."

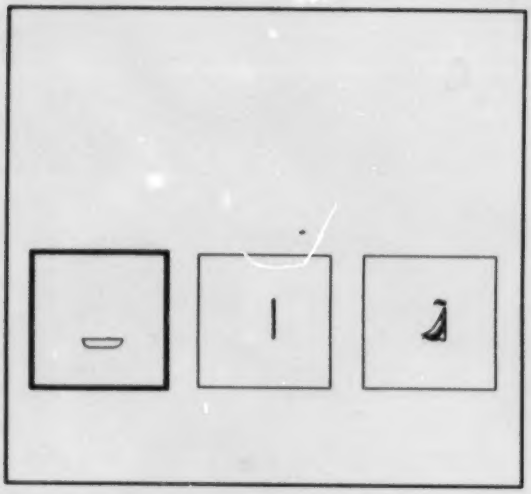

Fig. 54

"Touch the next box."

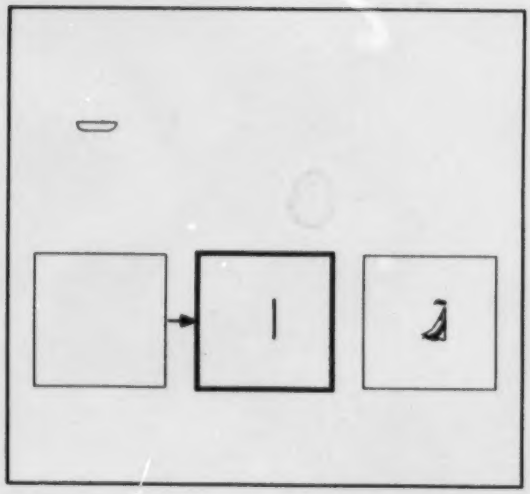

Fig. 55

"Touch the next box."

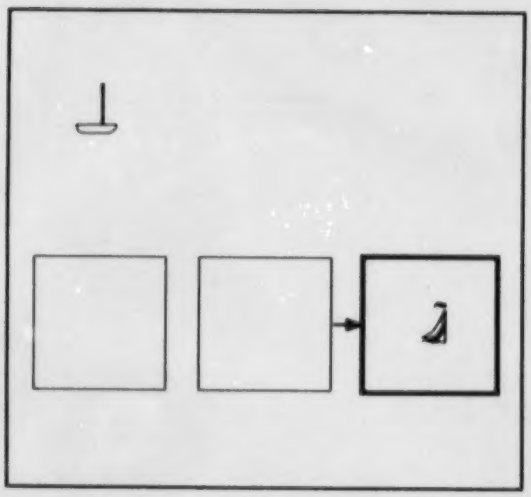

Fig. 56

"Look. I built a boat."
(Press NEXT.)

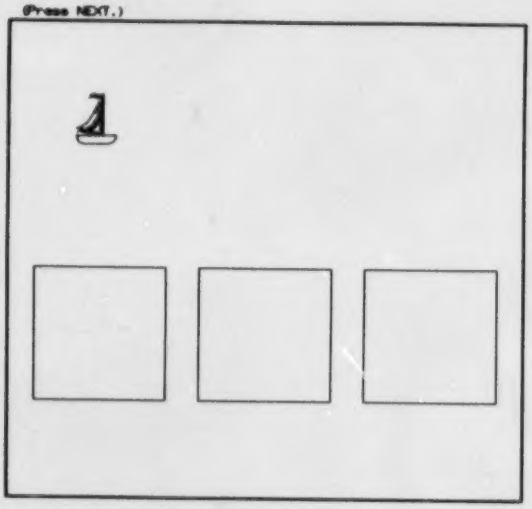

Fig. 57

"Your turn."
(Press NEXT.)

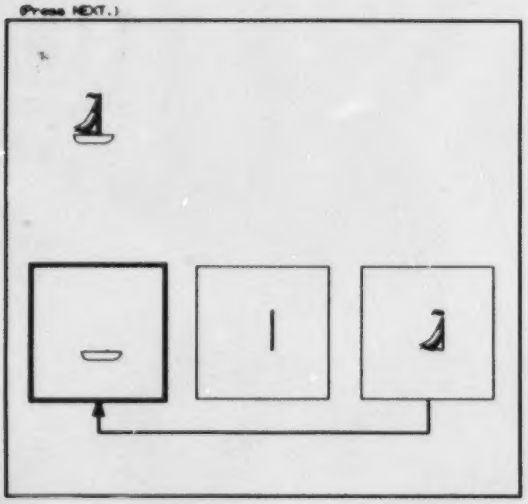

Fig. 58

"Touch."
(Lead if necessary.)

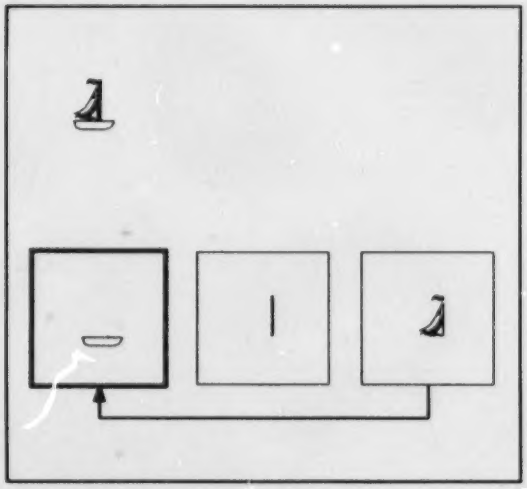

Fig. 59

"Touch the next box."

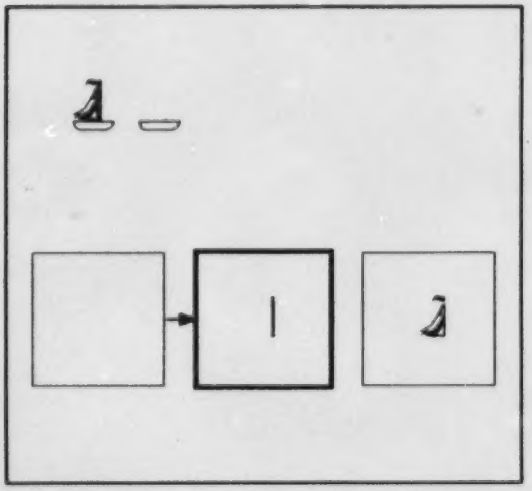

Fig. 60

"Touch the next box."

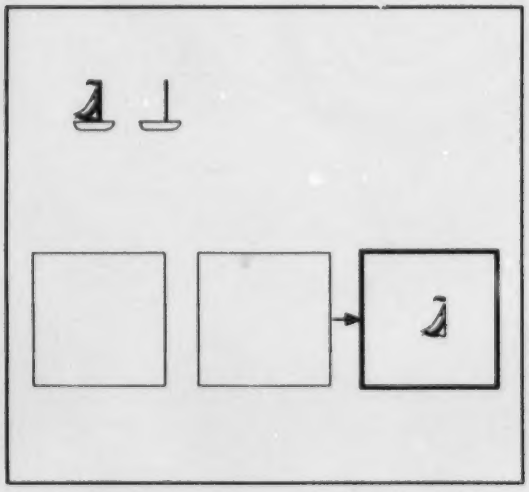

Fig. 61

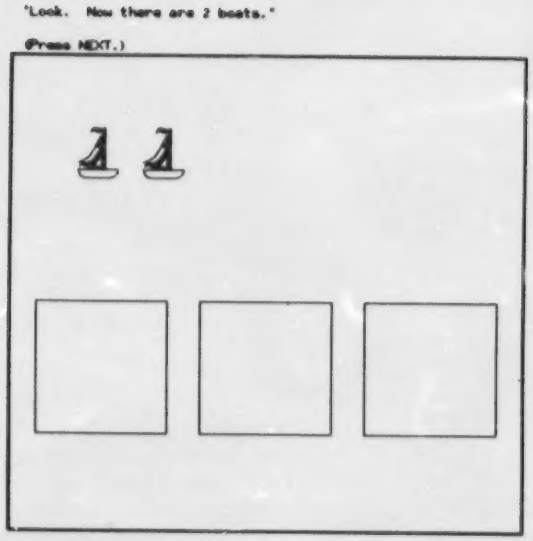
'Look. Now there are 2 boats.'
(Press NEXT.)

Fig. 62

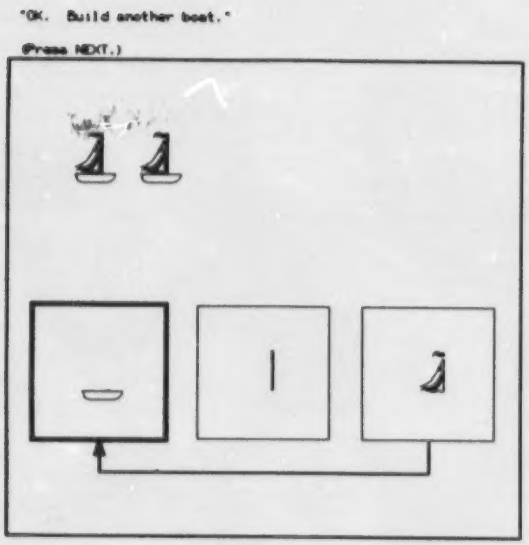
'OK. Build another boat.'
(Press NEXT.)

Fig. 63

A sorting format

"Look. This bag is for stars."
(Touch the left bag.)

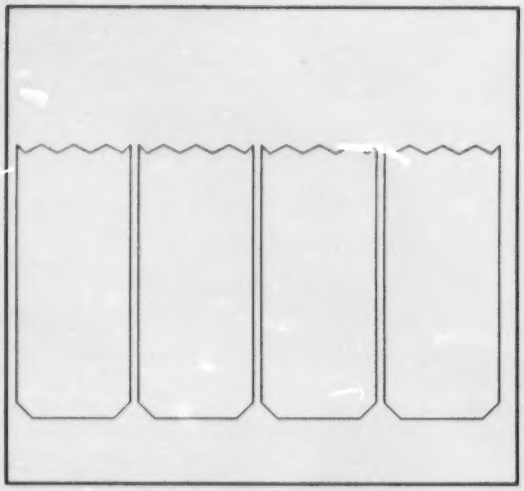

Fig. 64

"This bag is for bears."
(Touch the next bag.)

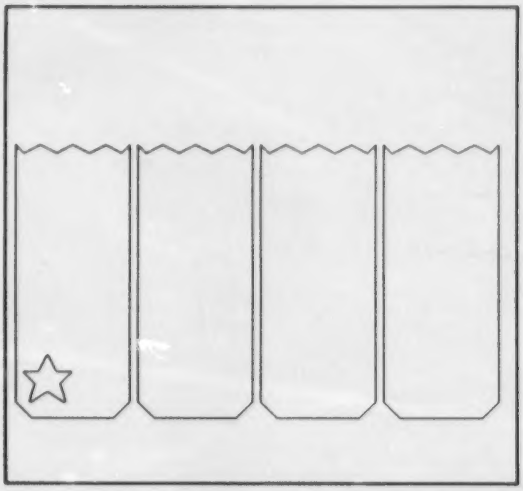

Fig. 65

This bag is for apples."
Touch the next bag.)

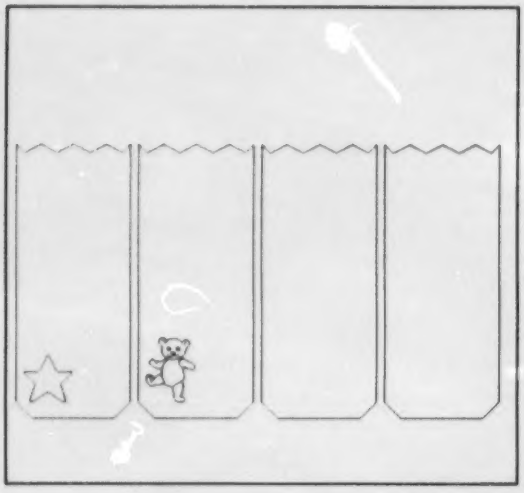

Fig. 66

"This bag is for balls.
(Touch the right bag.)

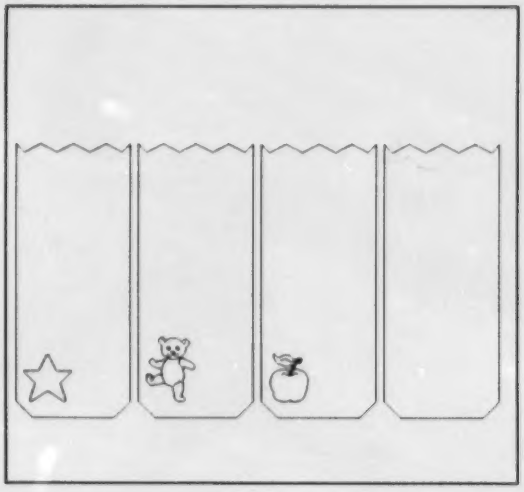

Fig. 67

"My turn. Where does the star go?"
(Model pointing behavior. Touch the star.)

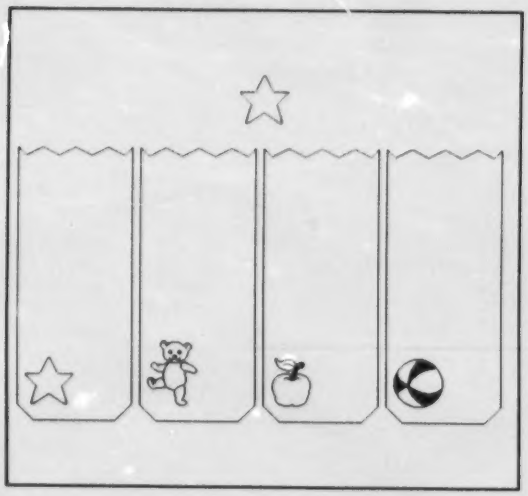

Fig. 68

"It goes here."
(Touch the appropriate bag.)

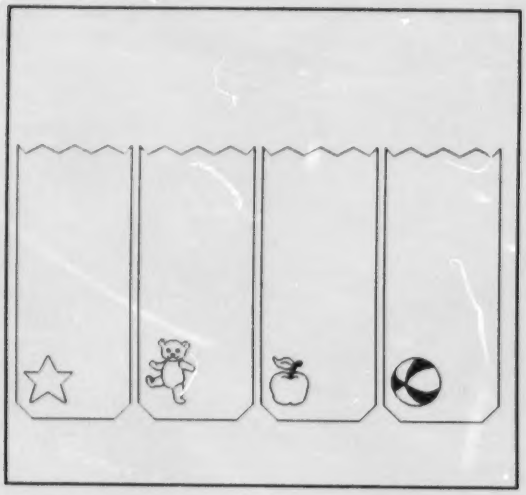

Fig. 69

"Where does the bear go?"
(Model pointing behavior. Touch the bear.)

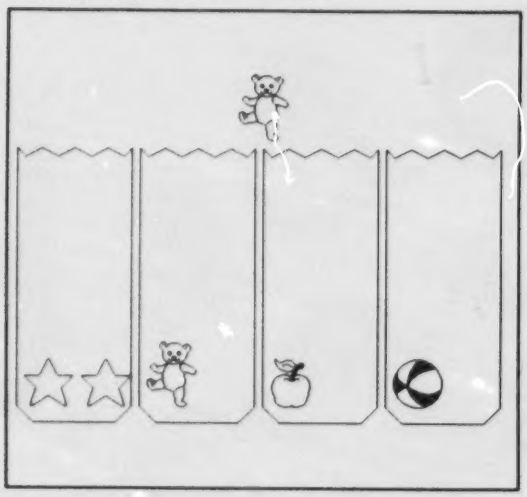

Fig. 70

"It goes here."
(Touch the appropriate bag.)

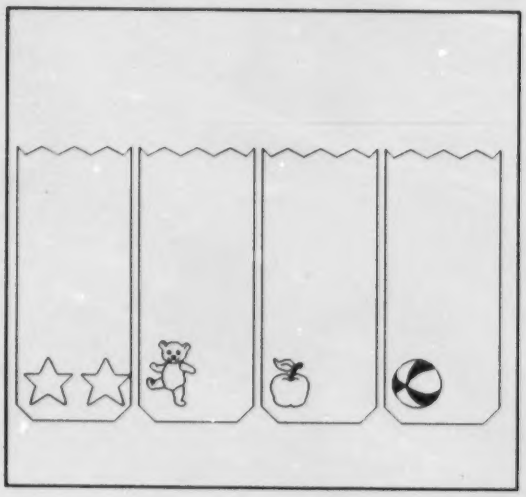

Fig. 71

"Your turn. Where does the bear go?"

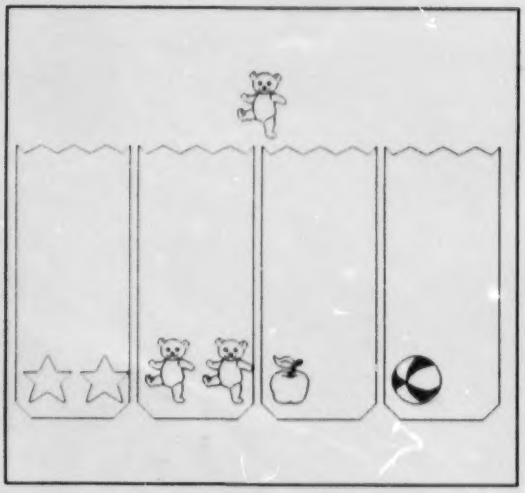

Fig. 72

"Where does the star go?"

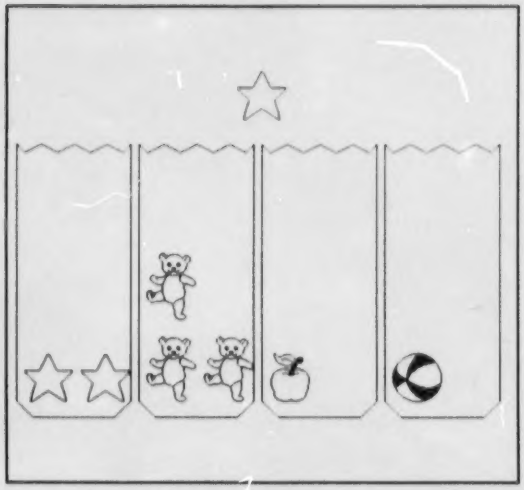

Fig. 73

"Where does the apple go?"

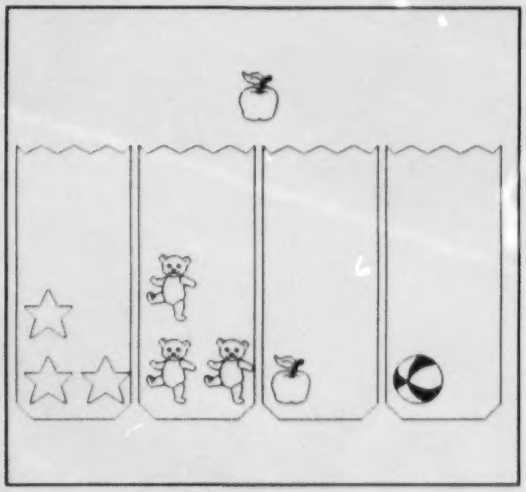

Fig. 74

(Press NEXT.)

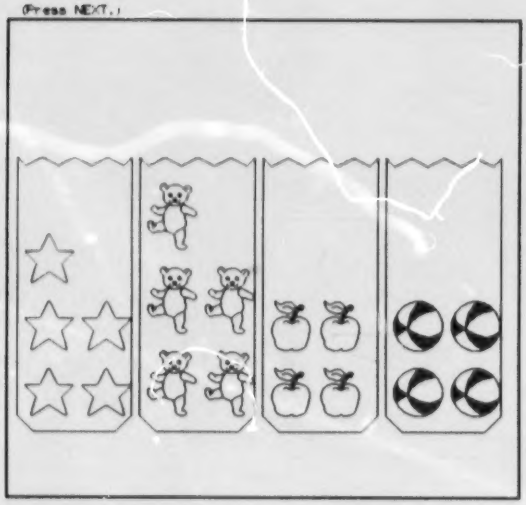

Fig. 75

Description of Formats Developed

The following is a brief description of the 108 formats developed during this project. Note that instructional lessons were designed by sequencing the formats in various ways, often using a particular format several times. Different objects were used with each of these formats, thus creating a wide variety of tasks.

# Formats	Description
29	Touch single and multiple objects on the screen; identify objects used in later formats.
4	Identify numbers 1 - 10 and letters in the student's name.
3	Count objects and answer the question "How many?
1	Draw shapes on the screen by touching dots.
24	Identify objects that are on, over, under, next to, and between.
4	Sort two - four objects.
2	Identify actions of objects.
39	Identify polar (opposite) attributes of objects.
2	Sequence actions.

Evaluation of Lesson Formats

Formative evaluation. Data was used to revise lessons until a final version was achieved. Criteria for identifying "final" versions were:

1. That students and tutors could use the lessons smoothly and with confidence, without the help of the lesson designers. The lessons were designed for use with a human tutor. The role of the tutor was to read aloud directions shown on the display screen, to assist students having difficulties which cannot be detected or remediated on-line, and to report observations via "comment".

2. That students and tutors enjoyed working with the lesson. In all cases, students and tutors should have felt that they understood and were in control of the interaction. The activity should have been such, moreover, that it invited future interaction and built positive attitudes toward learning.

3. That the lessons appeared to teach efficiently and effectively the intended skill. Information on which to base this preliminary

judgement was derived from the observations of tutors and from off-line tests. Final evaluation of lesson effectiveness by formal means were not conducted until the summative evaluation in the last six months of the project.

The design staff augmented the existing lessons, added more lesson concepts, finalized existing lessons, and attached data collection routines. The programming staff worked closely with the designers to bring the lessons to completion.

Summative evaluation. Procedures included:

1. Structured interviews with students, teachers and administrators. Interviews were used to determine whether or not the lessons a) promoted positive attitudes toward learning, b) interfered with and hopefully enhanced, the quality of social interaction among students and educational staff, c) promoted good staff morale, and d) constituted an administrative burden.

2. Evaluation of data collected on-line as students worked through the lessons. Since students were not allowed to progress to the next lesson in a developmental sequence until they mastered the previous lesson, position in the sequence alone would be an indicator of level of achievement.

3. Students were pre- and post-tested on achievement skills. Tests consisted of criterion-referenced tests developed specifically for the PLATO lessons. See Appendix B for a copy of the test.

As noted earlier, any sequence could be organized with the 108 different formats and multiple objects. Forty-four different sequences were developed for the summative study. Not all sequences were given to all students. Some sequences were non-verbal (e.g., required the student to identify objects by touch rather than by name) and, therefore, would not be assigned to students who could verbalize simple information. Each sequence took about 20 to 30 minutes to complete and could be interrupted by the tutor at the conclusion of any format in the sequence (and resumed later with the next format in the sequence).

A tutor presented no more than one sequence per day and often less. At the conclusion of each format in the sequence, the tutor was given the option to a) continue to the next format, b) repeat the last format, or c) end the session (see Figure 76). Appoximately half of the 44 sequences were presented to the students. The average time to complete these sequences was eight weeks.

Results. The 12 Howe students that participated in the study were pre- and post-tested on the test presented in Appendix B. The mean score on the pretest was 34.2 (s.d. = 33.7), and the mean score on the posttest was 54.2 (s.d. = 25.2). The scores represented the percent correct on the test. The gain of 20 points was statistically significant (alpha = .05) using a

correlated t-test [t(11) = 2.820, p = .0083]. The percent of variance accounted for by this effect was 42% of the sample variance and an estimate of 36.7% of the population variance. Although there was no control group used in this study, the tutors and instructors reported during the interviews that the students made substantial achievement gains, and that these gains were often accompanied by increased attention spans and on-task behavior. Not only were the gains statistically significant, but the teachers felt that the changes were eductionally significant as well.

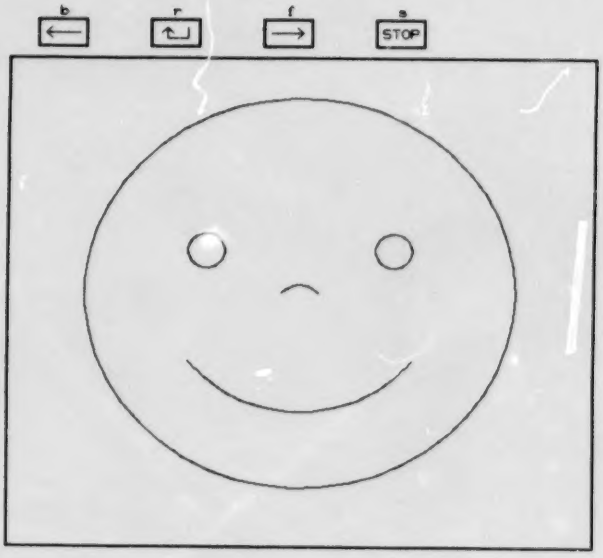

Fig. 76

CONCLUSIONS

Benefits Realized from the Work on PLATO

Experience gained in the Howe and Adler projects revealed the following benefits of PLATO instruction for the developmentally disabled:

1. PLATO motivates students to learn. Students who tend to reject other forms of instruction are eager to learn through PLATO. Teachers at Adler School observed that students are scrupulously on time for PLATO activities, whereas they tended to lag for other forms of instruction. PLATO was also used successfully as a reward when students finish other forms of academic work.

2. PLATO promotes a positive emotional tone. Even students for whom tantrumming in the classroom was virtually a daily episode remained calm and focused while working on PLATO. Students quickly learned that PLATO cannot be emotionally manipulated. As a result, distracting behaviors common in interactions with human teachers were reduced or eliminated.

3. PLATO improves skills of attending and following directions. The pacing of instruction on PLATO is more apparent to a developmentally disabled person than it is to that same person in the classroom setting. This awareness of pacing could be seen in the student's correct anticipation of the next response required in a lesson sequence. Teachers reported that well-structured sequences perceptibly improved students' patterns of attending in classroom and social activities. Several severely retarded individuals, who typically displayed high frequency self-stimulating behaviors, were observed to display no such behaviors while using PLATO.

4. PLATO stimulates language skills. Two aphasic children were observed to begin to engage in purposeful linguistic behavior after several months of working on PLATO. One of these students, an eight-year-old child with Apert's syndrome, said her first word while working on PLATO, in reference to something that she had made happen on the screen. The close correspondence between what the student does, what he hears through the earphones, and what he sees on the screen is apparently a stimulus to language development.

5. PLATO is perceived as a "friendly" medium by students. Numerous anecdotal reports cited the students' positive feelings toward PLATO, including several instances of actually hugging the terminals.

6. PLATO is perceived as an approachable and viable educational medium by staff as well as by parents of residents. The overwhelming majority of staff and parents who observed PLATO in use by residents concluded that this technological development

promised benefits to the developmentally disabled in a very positive fashion.

PLATO System Features Valuable to the Developmentally Disabled

The positive results described above are attributed to a number of PLATO system features which show particular promise in instruction for the developmentally disabled. These features are discussed below.

1. Instantaneous feedback. PLATO's ability to provide consistent feedback within a fraction of a second through visual and/or auditory channels clearly will benefit the developmentally disabled residents, since feedback is an essential component of operant conditioning. As B. F. Skinner stated: "The importance of feedback is clear. The organism must be stimulated by the congruences of its behavior if conditioning is to take place" (Skinner, 1953, p. 67). The fact that PLATO has the capability of providing feedback in more than one mode further enhances the impact of the feedback.

2. Multisensory presentation. PLATO lessons have both an auditory and a visual component. Well-designed lessons on PLATO give brief, simple auditory messages and carefully designed visual displays in controlled sequences. The learner has a chance to see clearly the relationship between what he hears and what he sees. This direct relationship makes the auditory component easier to process, giving an important boost to the comprehension of persons with auditory processing problems. At the same time, students are highly motivated to attend to directions they receive over the headphones. Unless the directions are followed, activity on the screen ceases. Teachers of both normal and developmentally disabled students have observed that this attentiveness to language carries over into other activities.

3. Low distractibility. The various features of the PLATO system, enhanced by appropriate programming, reduce the distractors normally present in a traditional instructional environment. The persistence of students with "low attention spans" in pursuing tasks on PLATO has been observed by teachers both of normal and of developmentally disabled students. The attention-holding quality of the PLATO system can be attributed, in part, to the emotional neutrality of PLATO. Students quickly learn that PLATO cannot be emotionally manipulated. For this reason, students working on PLATO tend to remain on-task even though their emotional problems lead to distracting behavior in other educational settings. They quickly realize that nothing is to be gained by tantrumming or engaging in other distracting behavior.

4. Active learning. Unlike record players, tape recorders, or television, which operate independently of the activity of the student, PLATO does not progress unless the student makes input. With PLATO, the student is necessary to the operation of the

device. This situation leads to a high level of responding. With other electronic media the student is unnecessary to the operation of the machine. Students respond positively to being in control, and they are highly motivated to attend since, without their participation, the interesting activity on the screen ceases. Supported by appropriate feedback and reinforcement, this high level of student response is necessary for effective teaching.

5. Individualized instruction. PLATO teaching programs can respond individually to students. Based on student input, the lesson will branch to one of a number of alternatives following instructional steps. This next step may be a remedial sequence, additional information at the same level, or the next step forward in a developmental sequence. PLATO'S flexibility in calling up programs and branching differentially, according to the student's response, are essential components for this population. The concept of intrinsic programming or "branching" was originally developed by Crowder (1958) and, according to Brown and L'Abate (1969), successful programmed instruction for a retarded population must adhere to an advanced branching model to individualize instruction and to obtain more extensive student involvement in the process.

6. Controlled instructional design. Carefully structured lessons are critical for learners with severe disabilities. Typical teaching programs for the mentally retarded may end up with staff working at cross-purposes if they do not rigorously adhere to the developed program (Bigelow 1974). Computer-based programs permit a greater degree of control of instructional parameters than is normally available in other instructional media. For example, drill paradigms can be maintained which correct, keep track of and bring back missed items according to a pattern specified by the instructor (Siegel and DiBello, 1980). With even a relatively small number of items, a human teacher would not be able to keep track of the items, the algorithms, and the student's performance. PLATO, however, can operate such a drill paradigm with high complexity over any desired period of time and for virtually any number of students.

7. Limitless repeatability. Intense repetition of instructional sequences with variability of examples controlled is often of key importance in teaching persons with poor memory (Foster and Keilitz, 1975). Uncontrolled presentation of examples may serve to block the development of generalizations which lead to more complex forms of behavior. Programming instructional sequences through PLATO can effectively eliminate unwanted variation and enhance instructional effectiveness.

8. Versatility of instruction. Furthermore, the fact that PLATO has proven to be a "fun," while educational, device in many applications (Manteuffel, 1976), holds promise for developmentally disabled persons who have been unresponsive to other teaching approaches.

With regard to recreational programming, the ability of PLATO to provide highly reinforcing and interactive recreational programs is amply demonstrated. More than 100 board games, card games, games of chance, maze-tracing, number games, puzzles, sportsgames, strategy games, target-shooting, and word games, among others, are already available on-line (Lyman, 1977a). These games cover a wide range of difficulty levels, require varying degrees of skill, and may be played with either one or several players at one time.

9. Data collection, storage and retrieval. Since habilitative strategies for the developmentally disabled represent an imperfect and evolving technology, the data collection, storage, retrieval, analysis, and summarization capabilities of the computer-based system are powerful assets in program development and research for these persons.

Recommendations

The use of computer-based instruction (CBI) with the developmentally disabled seems to be most attractive, viable, and effective. Both institutions have continued to use PLATO after the initial funding period.

Optimal use with the developmentally disabled is possible, however, only with clear committment from the institutions involved. In order for CBI to be maximally effective, it cannot be used simply as just another educational device. It must be integrated with the total environment of the developmentally disabled person. This implies a sponsor team working very closely with the institution so that the lessons on the computer and daily life are closely parallelled. For instance, a sorting task on the computer is more likely to be generalized to a real-life task if the graphics used for the computer task are based on the objects the individual would be using in a real-life task. Further, responses elicited from a developmentally disabled individual during instruction on the computer need also to be elicited from that individual in other situations if the responses are to become a permanent, generalized part of the individual's behavioral repetoire.

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Appendix A

Area #1: Introduction to Using PLATO

Introduction to Using PLATO

Area #2: Computer Managed Instruction

CMI Reading
CMI Language
CMI Math

Area #3: English Grammar and Usage

Using Words Correctly
Common Nouns
Words Commonly Confused
Capitalization
Commas and Periods
Proper Nouns
Subjects and Predicates
Double Negatives
A Lot About Pronouns
An Introduction to Sentences
Semicolons and Commas
Quotation Marks -- Direct Quotes
Direct Quotations
Passive Verbs
Introduction to Verbs
Introduction to Past Tense
Pronoun Agreement
Parts of Speech
Tiny Test on Grammar and Usage
Irregular Verbs
A Test on Hard Verbs
Possessives
Singulars, Plurals and Possessives
Verb "to be" -- Drill With Pronouns
Writing Good Paragraphs

Area #4: Vocabulary and Spelling

Wordstudy I and II
Wordstudy III and IV
Wordstudy V and VI
Drill on 101 Misspelled Words
Hangman -- A Word Game
Spelling Rules and Practice
Spelling Practice

Area #5: Decoding and Beginning Reading

Decode (with tutor)
Orientation to Beginning Reading

Concept Words and Stories
Words With the Same First Letter
Word Families, Add Beginning Letter
Word Families, Add Ending Letter
Memory Games
Word Drills, Acrobat - Candle
Word Drills, Car - Full
Word Drills, Gate - Jar
Word Drills, Kangaroo - Nest
Word Drills, Not - Run
Word Drills, Sad - Umpire
Word Drills, Under - Zipper
Calendar Drills
Word Games

Area #6: Reading Comprehension

Reading Comprehension I
Reading Comprehension II
Reading Comprehension III
Reading Comprehension IV
Pacer Passages I
Pacer Passages II
Pacer Passages III
Pacer Oassages IV
Pacer Passages V
Pacer Passages VI
Pacer Passages VII
Pacer Passages VIII
Pacer Passages IX
Pacer Passages X
Pacer Passages XI
Pacer Passages XII
Pacer Passages XIII
Reading Passage 1-- American Indians
Reading Passage 2-- Alexander Bell
Reading Passage 3-- Higher Education
Reading Passage 4-- American Holidays
Reading Passage 5-- Growth of Education
Reading Passage 6-- Dr. King, Jr.
Reading Passage 7-- National Parks
Reading Passage 8-- Transportation
Reading Passage 9-- Yellowstone Park
Reading Passage 10-- Labor Unions

Area #7: Adddition, Counting, and Place Value

Adding Lengths
Addition Facts Drill
Easy Hop
Adding Dots
Addition With Sticks

Place Value Drill
Adding and Carrying
Column Addition
Addition Checkup

Area #8: Subtraction

Subtraction With Tanks
Subtraction With Sticks
Vertical Subtraction
Subtraction Boxes
Subtraction Facts Drill
Subtracting in your Head
Subtraction Checkup

Area #9: Multiplication

Multiplication Sentences
Figuring out Multiplication No. 1
Figuring out Multiplication No. 2
Multiplication Facts Drill
Multiplication Step by Step
Multiplication by Putting Together
Multiplication Check-up
Rectangles, Areas, Multiplication

Area #10: Division

Meaning of Division
Division on the Number Line
Figuring out Division
Long Division
Division by Repeated Subtraction
Division Algorithm Introduction
Division Algorithm
Division Step by Step
Division Check-up

Area #11: Whole Number Arithmetic Consolidation

Mental Arithmetic
Addition and Subtraction Speedway
Torpedo (Whole Numbers)
Problem Machine
Pinball Number Facts Machine
Multiplication and Division Facts Drill
Operations Practice
Speedway Race on Number Facts
Parentheses
Basic Word Problems

Area #12: Fractions

Meaning of Fractions Check-up
Mixed Numbers (Pizza)
Mixed Numbers Drills
Equivalent Fractions Drills
Equivalent Fractions -- Simplest Terms
Mixed Numbers Check-up
Equivalent Fractions Check-up
Fractions Darts
Add and Subtract Like Denominators
Practice Addition and Subtraction Like Denominators
Addition and Subtraction Like Denominators (Borrowing)
Addition and Subtraction Like Denominators Check-up
Basketball (Like Denominators)
Fractions Torpedo
Practice Addition and Subtraction Unlike Denominators No. 2
Addition and Subtraction Unlike Denominators Check-up
Finding the Lowest Common Denominator
Basketball (Unlike Denominators)
Multiplication of Mixed Numbers
Multiplication of Mixed Numbers Check-up
Practice Multiplying Mixed Numbers
Arithmetic Operations on Fractions
Ratios and Proportions

Area #13: Decimals and Percents

Meaning of Decimal Fractions No. 1
Meaning of Decimal Fractions No. 2
Writing and Reading Decimals
Adding and Subtracting Decimals
Multiplying and Dividing Decimals
Rounding Decimals
Basic Math Review Drills
Keeping a Balanced Checkbook
Comparing Decimals and Fractions

Area #14: Algebra

Signed Numbers -- Adding and Subtracting
Multiplication and Division With Signed Numbers
Distributive Law and Collecting Terms
Beginning Algebra Word Problems Drills
Evaluating Algebraic Expressions
Introduction to Exponents
Binomial Products
Factoring Quadratic Polynomials
Linear Equations and Word Problems
Algebraic Fractions Drills
Graphing Straight Lines
Simultaneous Equations
Solving Quadratic Equations by Factoring

Area #15: Miscellaneous and Advanced Mathematics

Finding the Square Root of a Number
Simplifying Square Roots
Introduction to Sets
Practice With Metric Conversions
Scientific Notation
Geometry
Introduction to Trigonometry
Sine, Cosine and Tangent
Oblique Triangles
Conversion Factors

Area #16: Miscellaneous Topics

Beginning Typing
U.S. and Illinois Government

Appendix B

DMHDD ___PRE ____POST

Student's Name: _____

Today's Date: _____

Testor's Name: _____

____ 1a. Touch the ball. (ANS: Student touches the ball)

____ 1b. Is the ball...ON? (ANS: Yes)

____ 2a. Touch the star. (ANS: Student touches the star)

____ 2b. Is the star...ON? (ANS: No)

____ 3a. Touch the ball. (ANS: Student touches the ball)

____ 3b. Is the ball...OVER? (ANS: No)

____ 4a. Touch the star. (ANS: Student touches the star)

____ 4b. Is the star...OVER? (ANS: Yes)

____ 5a. Touch the star. (ANS: Student touches the star)

____ 5b. Is the star...UNDER? (ANS: Yes)

____ 6a. Touch the ball. (ANS: Student touches the ball)

____ 6b. Is the ball...UNDER? (ANS: Yes)

____ 7a. Touch the star. (ANS: Student touches the star)

____ 7b. Is the star...BETWEEN? (ANS: No)

____ 8a. Touch the ball. (ANS: Student touches the ball)

____ 8b. Is the ball...BETWEEN? (ANS: Yes)

____ 9a. Touch the football that is ON the bike.
(ANS: Student touches football #3)

____ 9b. Touch the football that is OVER the bike.
(ANS: Student touches football #1)

____ 10a. Touch the balloon that is UNDER the desk.
(ANS: Student touches balloon #1)

____ 10b. Touch the balloon that is ON the desk.
(ANS: Student touches balloon #4)

____ 11. Touch the boy that is BETWEEN.
(ANS: Student touches the boy in the middle)

____ 12a. Touch a pencil that is LONG.
(ANS: Student touches pencil #1 and/or #4)

____ 12b. Touch a pencil that is SHORT.
(ANS: Student touches pencil #2 and/or #3)

____ 13a. (Point to shoe #1)
Is this shoe...SHORT? (ANS: Yes)

____ 13b. (Point to shoe #2)
Is this shoe...SHORT? (ANS: No)

____ 13c. (Point to shoe #3)
Is this shoe...SHORT? (ANS: Yes)

____ 13d. (Point to shoe #4)
Is this shoe...SHORT? (ANS: No)

____ 14a. Touch a snake that is LONG.
(ANS: Student touches snake #1 and/or #2)

____ 14b. Touch a snake that is NOT LONG.
(ANS: Student touches snake #3 and/or #4)

____ 15a. (Point to pot #1)
Is this pot...FULL? (ANS: Yes)

____ 15b. (Point to pot #2)
Is this pot...FULL? (ANS: No)

____ 16a. Touch a wastebasket that is EMPTY.
(ANS: Student touches wastebasket #3)

____ 16b. Touch a wastebasket that is FULL.
(ANS: Student touches wastebasket #1 and/or #2)

____ 17a. Touch a jar that is NOT FULL.
(ANS: Student touches jar #1 and/or #3)

____ 17b. Touch a jar that is NOT EMPTY.
(ANS: Student touches jar #2 and/or #4)

____ 18. Where does the STAR go?
(ANS: Student touches bag #1)

____ 19. Where does the APPLE go?
(ANS: Student touches bag #4)

____ 20. Where does the BEAR go?
(ANS: Student touches bag #2)

____ 21. Where does the BALL go?
(ANS: Student touches bag #2)

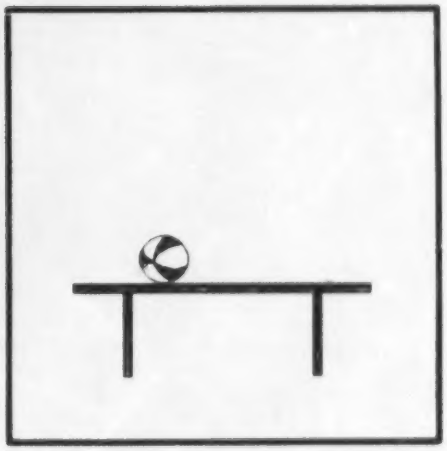
____ 22. Where does the APPLE go?
(ANS: Student touches bag #1)

____ 23. Where does the STAR go?
(ANS: Student touches bag #2)

TOTAL: _____

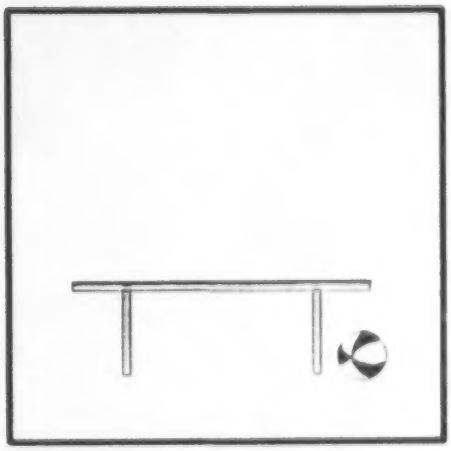
Comments:

Pictures used with test questions



Picture for questions 1a and 1b.

Picture for questions 2a and 2b.



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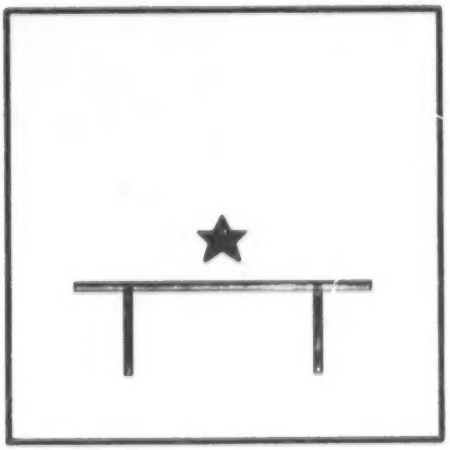

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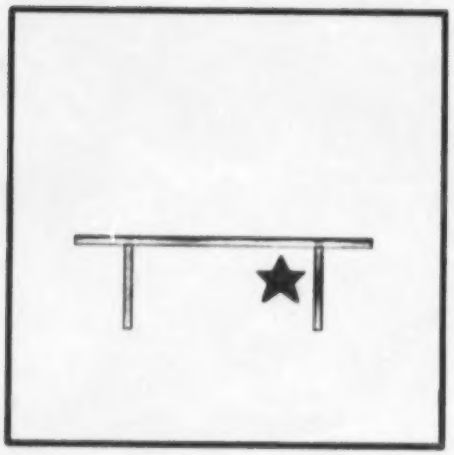

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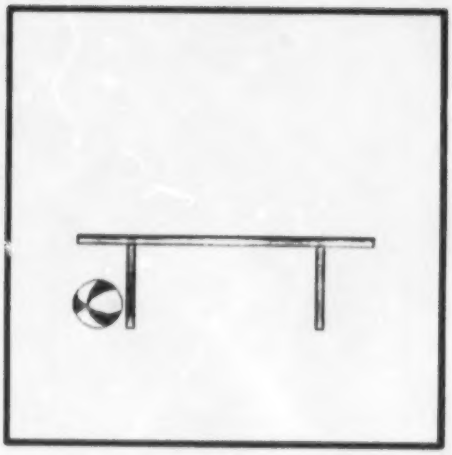
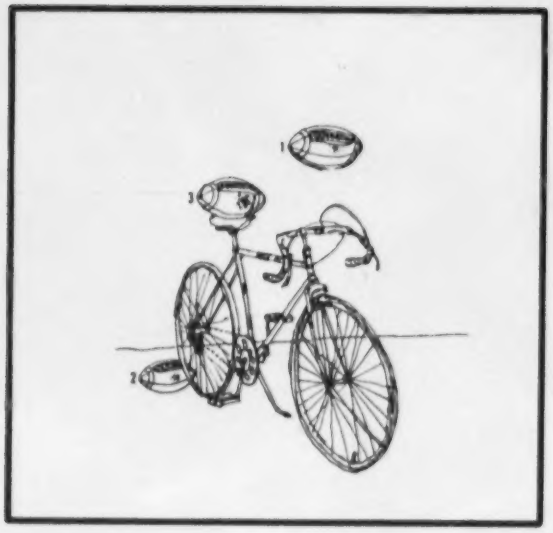


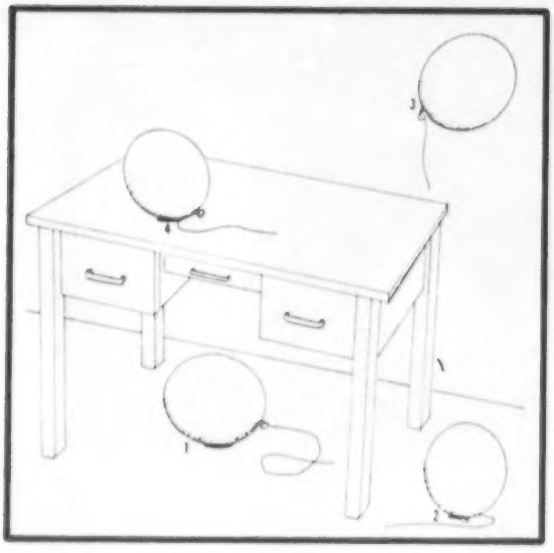
Picture for questions 6a and 6b.

Picture for questions 7a and 7b.

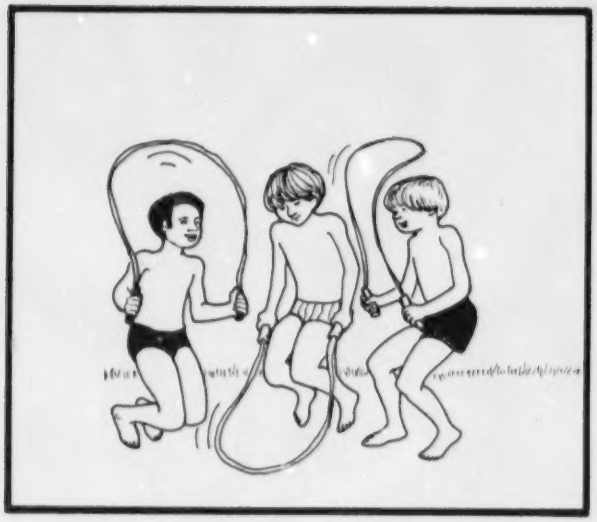
Picture for questions 8a and 8b.



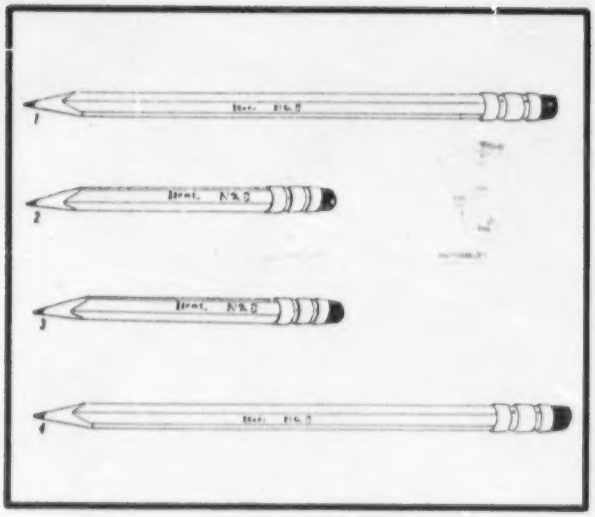
Picture for questions 9a and 9b.



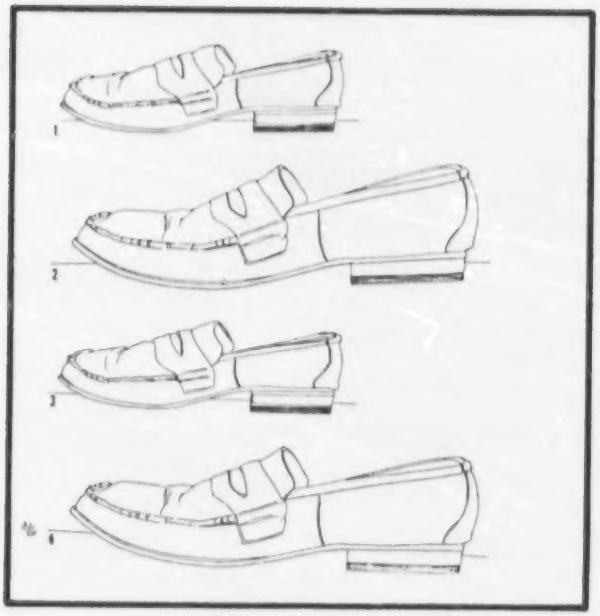
Picture for questions 10a and 10b.



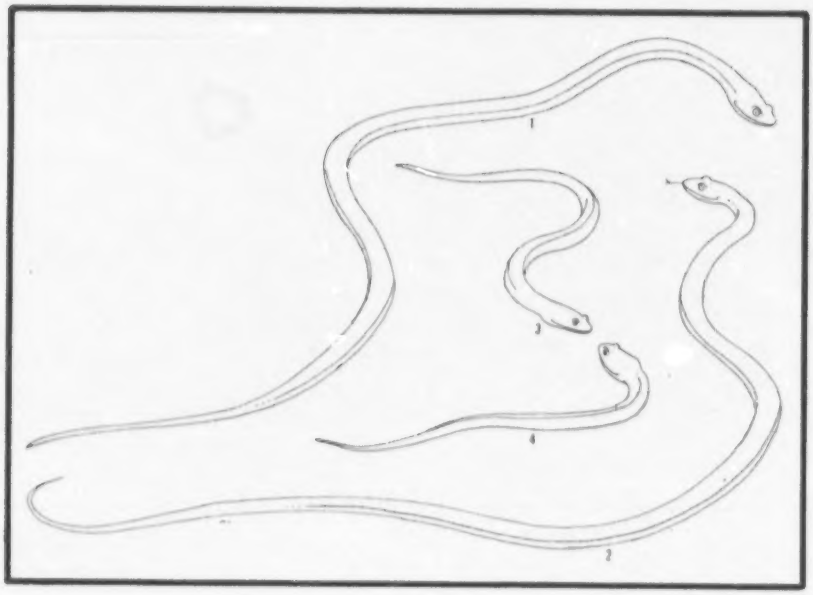
Picture for question 11.



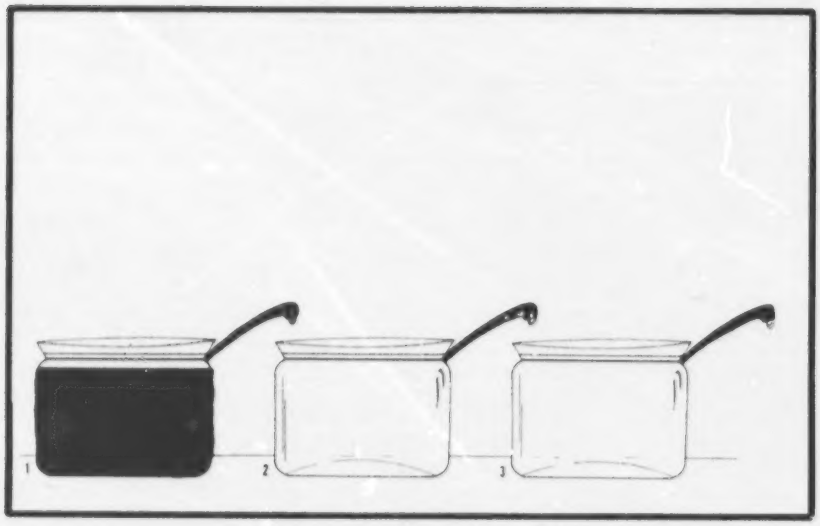
Picture for questions 12a and 12b.



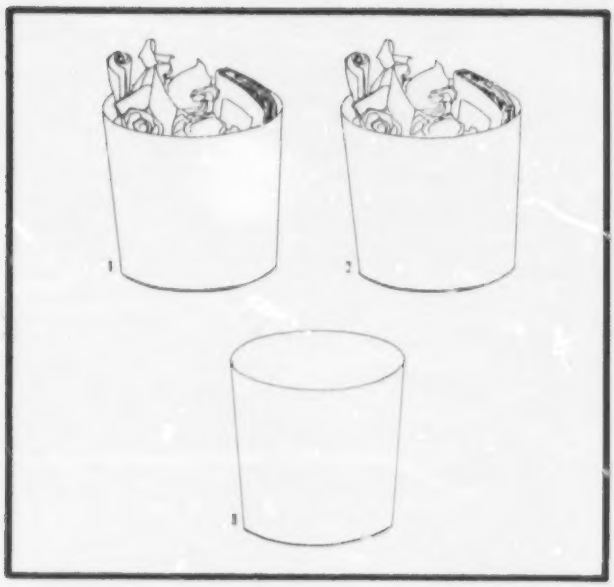
Picture for questions 13a, 13b, 13c, and 13d.



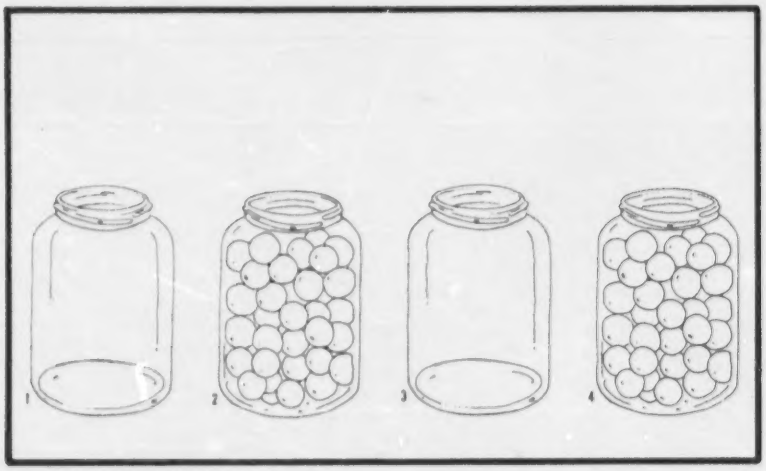
Picture for questions 14a and 14b.



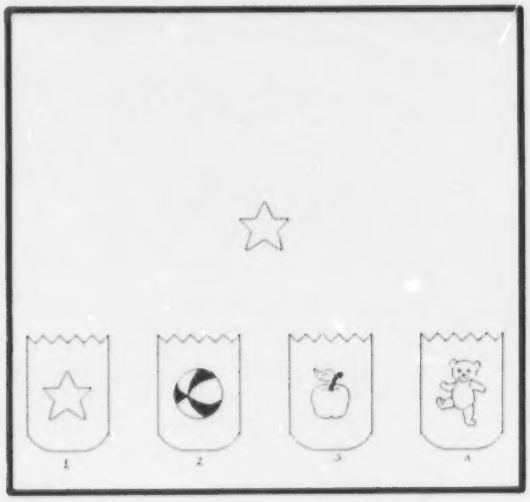
Picture for questions 15a and 15b.



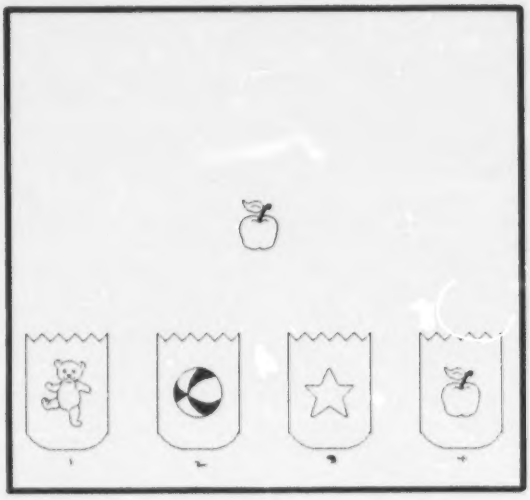
Picture for questions 16a and 16b.



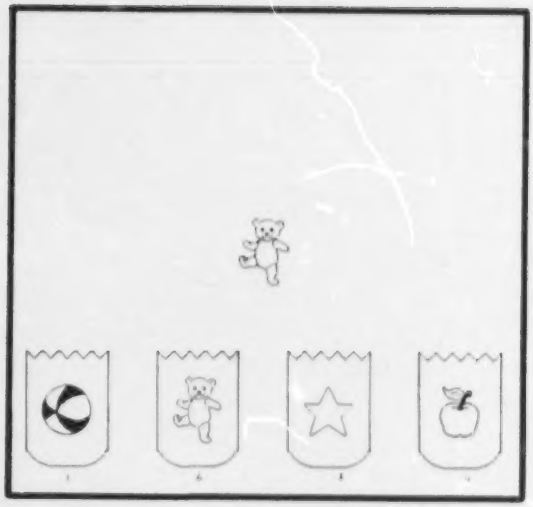
Picture for questions 17a and 17b.



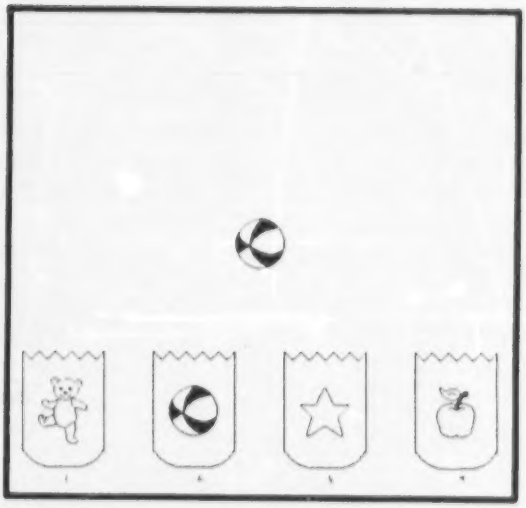
Picture for question 18.



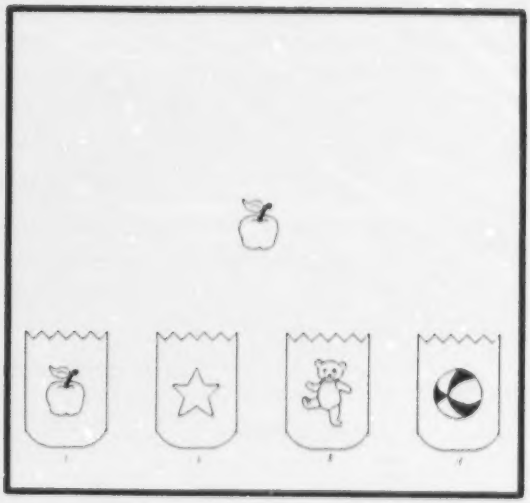
Picture for question 19.



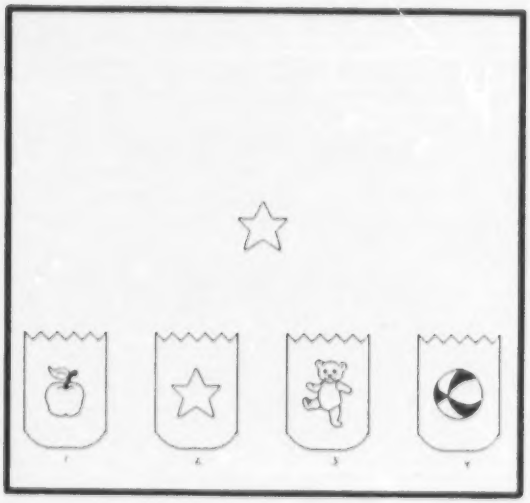
Picture for question 20.



Picture for question 21.



Picture for question 22.



Picture for question 23.